GENERAL REQUIREMENTS – ELECTRICAL EQUIPMENT

Contents

General Requirement – Electrical Equipment

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INTRODUCTION

This scope of this specification consists of general requirements of Design, manufacture, inspection and testing at manufacturer's works, supply, packing, forwarding and delivery to site, unloading, handling and storing the equipment at site, assembly, installation, testing and commissioning at site of the equipment/ system listed below as per Specifications, data sheets & Single Line Diagram. Particular requirements of all electrical equipments are covered under 'Part 12: Particular Requirements – Electrical' of this Specification.

a) Oil cooled Transformers
b) HT Switchgear Panels
c) 415V Metal enclosed switchboards (MCCs/PCCs)
d) 415 V Power capacitor and control panel
e) Bus Duct
f) Diesel Generator Set with Acoustic Enclosure
g) UPS
h) Battery, Battery charger and DC Distribution board
i) Cabling System: HV, LV, Control and Telecommunications
j) Cable carrier system,
k) Lighting
l) Lighting System Equipment
m) Earthing & Lightning protection system.

The equipment of those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The respective equipment should have been manufactured, supplied, installed, tested, Commissioned successfully and should be working satisfactorily since at least last 5 years continuously. Certificates from the end users, regarding their satisfactory performances, shall have to be submitted in this regard.

Various equipment /items shall conform to latest applicable standards specified. In case of Conflict between standards and this specification, this specification shall govern.

TRANSFORMERS

Transformer system shall have provision such that inter-opera ability with instrumentation controls system.

A. Applicable Standards

The transformers shall conform to the latest applicable standards specified below

Power Transformer	IS:2026/BS:171/ IEC:60076 IS11171
Fittings and Accessories	IS:3639
Outdoor type Oil immersed distribution transformers upto 2500kVA, 33kV Transformer	IS:1180-2014
Loading of oil immersed transformer	IS:6600/BS:CP.1010 /IEC:60354
Transformer Oil	IS:335/BS 148/IEC:60296
Bushings for > 1000V, AC	IS:2099/BS:223/ IEC:60137
Bushings for ≤ 1000V, AC	IS:7421
Degree of Protection	IS:13947 (Part 1) / IEC:60947-1
Double float type Buchholz Relay	IS:3637
Electrical insulation classified by thermal stability	IS1271/BS:2757/ IEC:60085
Climate Proofing	BS:CP1014
Code of Practice for selection, installation and Maintenance of transformers	IS - 10028
Manual on Transformers	CBIP Publication No.295

B. Features of Construction

a) The transformer tank shall be made from high-grade sheet steel, suitably reinforced by stiffeners made of structural steel sections.

b) All seams, flanges, lifting lugs, braces, and other parts attached to the tank shall be welded.

c) The interior of the tank shall be cleaned by sand blasting and painted with two coats of heat resistant, oil insoluble paint.

d) Adequately sized manholes shall be provided for ease of inspection and maintenance. Steel bolts and nuts exposed to atmosphere, shall be galvanized.

e) The tank cover shall be removable and shall be suitably sloped so that it does not retain rainwater.

f) Lifting lugs and eyebolts shall be so located that a safe clearance is obtained without the use of a spreader, between the sling and transformer bushings.

g) Transformers shall be provided with fixed type radiators. Fins of the radiators shall not have sharp edges and shall be rounded in shape.

h) The transformer core shall be constructed from high grade, non-ageing, cold-rolled, grain oriented, silicon steel laminations. The steel laminations shall be of "core" type. Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service. Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated. The framework and clamping arrangements of core and coil shall be securely earthed inside the tank by a copper strap connection to the tank.

i) Windings shall be of insulated copper wire or copper strip. Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core. The windings shall be fully shrunk under vacuum before assembly. High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.

j) The sequence and orientation of HV/LV side phase and neutral bushings shall be as specified in the latest edition of relevant IS.

k) Transformer shall operate without injurious heating at the rated KVA and at any voltage up to + 10 % of the rated voltage of any tap. Transformer shall be designed for 110 % continuous over-fluxing withstanding capability.

l) Transformer shall be provided with Zero sequence / earth fault current protection on LV side transformer feeder protection. (Neutral CT to be provided in case of solid grounding)

C. Winding connections

Windings shall be of HV:Delta & LV: Star, vector group Dyn 11.

D. Rating

The rating of transformers shall be as per standard ratings shown in IS 1180:2014 or relevant standard.

E. Type of cooling

The transformers shall be oil immersed with natural oil circulation, type ONAN. With the provision for radiator cooling with fans for forced cooling, if required will be added in future. The rating of the transformer with ONAF shall be specified.

F. Impedance and losses

The percentage impedance, no load & load losses shall be as per IS 1180: 2014 or relevant standard.

G. Performance requirements

(a) The transformers shall be suitable for operation without danger on to any particular tapping at the rated kVA provided that the voltage does not vary by more than ± 10 % of the voltage corresponding to the tapping.

(b) The transformers shall be suitable for continuous operation with a frequency variation of ±5% of rated frequency, combined voltage and frequency variation should not exceed 10 %.

(c) All transformers shall be capable of withstanding external short circuit without damage as per IS 2026.

(d) The transformers shall be capable of continuous operation in accordance with relevant IS for loading of oil immersed transformers.

(e) The neutral terminal of star windings shall be designed for the highest over current that can flow through this terminal.

(f) The temperature rise of oil & windings over the specified ambient temperature shall not exceed the limits given below with air as cooling medium when tested in accordance with IS 2026 (Part-2).

Top oil (measured by thermometer)	:	40° C
Winding (measured by resistance)	:	45° C

(g) Noise level of transformers shall be less than 80 dB at a distance of 1 metre.

H. Tap Changer

(a) The standard tapping range shall be +5% to -15% of HV in terms of 2.5 % with taps on HV Side.

(b) For transformer of rating less than or equal to 500 kVA, tap changing shall be carried out by means of an off circuit externally operated self positioning switch when the transformer is in de-energized condition. Off circuit tapping arrangement shall be either by means of an externally operated switch with mechanically locking device and a position indicator. Arrangement for pad-locking shall be provided.

(c) On Load Tap Changing Gear for Transformer (above 500kVA)
The OLTC gear shall be designed to complete successfully tap changes for the maximum current to which transformer can be loaded i.e. 150% of the rated current. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.

(d) When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.

(e) Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. A Buchholz relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge.

(f) Oil in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valve pipe connections. Any gas leaving these compartments shall pass through the Buchholz relay before entering the conservator.

(h) OLTC driving mechanism and its associated control equipment (Local) shall be mounted in an outdoor, weather-proof cabinet with IP 55 protection which shall include :

(i) Driving motor (415V, 3-phase, 50 Hz. AC squirrel cage).
(ii) Motor starting contactor with thermal overload relays, isolating switch and HRC fuses.
(iii) Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa.
(iv) Control switch: Raise/off/lower (spring return to normal type).
(v) Remote/local selector switch (maintained contact type).
(vi) Mechanical tap position indicator showing rated tap voltage against each position and resettable maximum and minimum indicators.
(vii) Limit switches to prevent motor over-travel in either direction or final mechanical stops.
(viii) Brake or clutch to permit only one taps change at a time on manual operation.
(ix) Emergency manual operating device (hand crank or hand wheel).
(x) A five digit operation counter.
(xi) Electrically interlocked reversing contactors (preferably also mechanically interlocked).
(xii) 240V, 50 Hz. AC space heater with switch and HRC fuses.
(xiii) Interior lighting fixture with lamp door switch and HRC fuses.
(xiv) Gasketed and hinged door with locking arrangement.
(xv) Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
(xvi) Necessary relays, contactors, current transformers etc.

(g) Control Requirements for OLTC

The following electrical control features shall be provided:

(i) Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.

(ii) Only one tap change from each tap change impulse even if the control switches or push button is maintained in the operated position.

(iii) Cut-off of electrical control when manual control is resorted to. Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.

(iv) Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

(h) Automatic Control of OLTC: Automatic OLTC control shall include the following items:

(i) Voltage setting device

(ii) Voltage sensing and voltage regulating devices.

(iii) Line drop compensator with adjustable R and X elements.

(iv) Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation

(v) Adjustable dead band for voltage variation

(i) The OLTC remote control equipment shall be housed in an indoor sheet steel cubicle to be located in a remote control room. It shall conform to degree of enclosure protection IP42 or better and shall comprise the following.

(j) The OLTC control panel shall comprise of rigid welded structural frames made of structural steel section or of pressed and formed cold rolled steel and frame enclosures, doors and partitions shall be of cold rolled steel of thickness 2 mm. Stiffeners shall be provided wherever necessary.

(k) All doors, removable covers and plate shall be gasketed all around with neoprene gaskets. Panel shall be dust, weather and vermin proof providing degree of protection of IP54, colour of finish shade for interior and exterior shall be glassy white and light grey semi glossy shade 631 of IS-5 respectively.

(l) Min. Size of earthing bus shall be of 25 x 6 mm copper.

(m) The OLTC remote control equipment shall comprise of the following

(i) Control switch:Raise/Off/Lower (spring return to normal type)

(ii) Auto/manual selector switch (maintained contact type)

(iii) Tap position indicator

(iv) Facia type alarm Annunciators with “accept” and “lamp test” facilities.

- A.C. supply failure
- Drive motor auto tripped

- Tap change delayed

(v) Necessary auxiliary relays

(vi) Lamp indications for :
- Tap change in progress
- Lower limit reached
- Upper limit reached

(vii) Cable glands for power and control cables.

(viii) 240 V rated panel space heater with ON-OFF switch.

(ix) Fluorescent type interior lighting fixture with lamp and door switch.

(x) HRC fuses.

(xi) Terminal blocks.

(xii) Internal wiring.

(xiii) Earthing terminal.

I. Fittings and Accessories

The following fittings and accessories shall be provided for transformer:

(a) Inspection manhole(s) with cover(s) on the top cover of the transformer.

(b) Lifting lugs or eyes for lifting of fully assembled transformer by crane.

(c) Jacking pads, at least four in number, at suitable height, for lifting the complete transformer filled with oil.

(d) Lifting arrangements for
(i) Complete transformer filled with oil
(ii) For the assembly of core and coils and
(iii) For lifting the tank of large transformers whenever specified.

(e) Hauling eyes on each face of the transformer (for transformer rated 10000 KVA and above).

(f) Skids at the base of the transformer.

(g) A ladder assembly shall be provided to reach the top of the transformer for maintenance work. It shall be possible to padlock the ladder to the transformer tank so that ladder cannot be removed. Usage of transformer structure / marshalling boxes etc as means to climb transformer are not acceptable.

(h) Earthing pads: Two earthing pads of copper or other non-corrodible material shall be welded at the bottom corners of the transformer tank and supplied with clamp type terminals suitable for the Employer's earthing conductors. Suitable earthing terminals on cable boxes and separately mounted radiator banks shall also be provided.

(i) Neutral earthing bar of copper of specified section installed from the neutral bushing to ground level suitably supported along its run on porcelain insulators, together with clamping arrangements at neutral bushing and for two Employer's earth conductors. The supporting insulators shall be tank mounted.

(j) Terminal marking and rating plates shall be as per the specified standard and shall also give the following additional information:

(i) Connection diagram showing the internal connections.

(ii) Guaranteed Temperature rise of winding and oil.

(iii) Insulation levels of the windings, including neutral end of windings with uniform insulation.

(iv) Transportation weight.

(v) Un-tanking weight.

(vi) Core and winding weight.

(vii) Table giving the tapping voltage, tapping current and tapping power factor for each tap. Values of short circuit impedance on the extreme tappings and on the principal tapping and indication of the winding to which the impedance is relates.

(k) The transformer shall also be provided with the following non-corrodible plates, indelibly marked showing:

(i) Location and function of all valves and plugs and indication of the maintenance instrument reference for applying vacuum of drying and oil filling.

(ii) Valves connection diagram

(l) The conservator shall be provided with the following accessories:

(i) Filling plug, sump and drain valve of 15 mm size for conservator of size 650 mm and 25 mm size for conservator above 650 mm diameter.

(ii) 150 mm diameter magnetic type oil level gauge with low oil level alarm contacts and a prismatic oil sight gauge, both as specified in Data Sheet and provided with markings for minimum oil level and oil level at rated temperature rise.

(iii) A bolted cover at one end for cleaning.

(iv) Valve for shutting off oil to the transformers.

(v) Weather proof dehydrating breather with silica gel and oil seal to eliminate constant contact with the atmosphere, mounted at a level of about 1400 mm above ground level.

(m)Gas and Oil Actuated Relay (Buchholz Relay)

(n)Temperature Indicators

(o) Dial Type Thermometer

(p) Winding Temperature Indicator

J. <u>Cable Terminations / Cabling Requirement</u>

11kV air insulated cable box with air insulated disconnecting chamber shall be provided with supporting brackets and structure to facilitate their supportfrom ground level. The disconnecting chamber and terminal box shall be air insulated andcomplete with seal-off bushings, removable flexible connectors/links and removable covers. LT terminal box shall be suitable for connecting LT air insulated bus duct.

All transformers shall be provided with lockable emergency Push Button station near the transformer to trip the transformer as per IER.All transformers shall be provided with alarm annunciation on breaker control panel.

K. Tolerance on Losses

The permissible tolerances on the guaranteed values of transformer losses shall be as per IS 2026. Cost loading shall be done for capitalization of losses at time of bid evaluation for all transformers as per CBIP Manual on transformers.

L. Rejection

(a) The Employer or Employer's Representative reserves the right to reject the transformer if the same does not meet the specification requirement, subject to tolerances as per IS 2026.

(b) The impedance values difference and temperature rise values shall not exceed from the guaranteed specified values.

(c) The rejected transformers shall be replaced by transformers complying with the requirements of this specification at the Contractor's cost.If the commissioning of the project is likely to be delayed by the rejection of a transformer, the Employer's Representative reserves the right to accept the rejected transformer until the replacement transformer is made available.

(d) Transporting the rejected and replacement transformers as well as installation and commissioning of both the transformers shall be at the Contractor's cost.

M. Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid/ after award of contract as specified under " Bid/Contract Drawings" , Part 3, General Requirements, Volume-2 of Bid Documents.

15.1 HV METAL ENCLOSED SWITCHBOARDS& SWITCHGEARS

HV/MV metal enclosed Switchboards and Switchgear system shall have provision such that inter-opera ability with instrumentation control system.

A. Applicable Standards

The switchgear and its components shall conform to the latest applicable standards specified below:

Circuit Breakers	IS : 13118 / BS : 5311 /IEC: 60056,60694,IEC 62271-100
Metal Enclosed switchgear	IS:3427/ BSEN:60298 / IEC:60298,

	IEC 62271-200
Current Transformers	IS : 2705 / BS : 7626
Voltage Transformers	IS : 3156 / BS : 7625 / IEC : 60186
Arrangement for Switchgear Busbars, Main Connections and Auxiliary wiring	IS : 5578, 11353
Busbar Support insulators	IS : 2544 / BS : 3297 / IEC :60 273
Degree of Protection	IS : 13947 (Part 1) /IEC : 60947-1/ BSEN : 60529
Electrical Relays for Power system protection	IS : 3231, 3842 / BS : 142 / IEC : 60255
Electrical Indicating Instruments	IS : 1248 / BS : 89 / IEC :60051
High Voltage Fuses	IS : 9385 / BS : 2692 / IEC : 60282
AC Electricity Meters	IS : 722, 8530 / BS : 5685 / IEC : 60145,60211
Specification for copper rods and bars for electrical purposes	IS : 613
Code of practice for phosphate iron and steel	IS : 6005 / BS : 3189
Alternating current Switches for voltages above 1000 V	IS : 9920 / IEC : 60129,60265 & 60298
Low voltage fuses	IS : 13703 / BS 1362 / IEC 60269
Toggle switches	IS : 3452 / BS : 3676
Code of practice for selection, installation and maintenance of switchgear and control gear	IS : 10118
Control switches	IS:6875 / BSEN 60947/IEC: 60947
Classification of Hazardous areas having Flammable gases and vapours for Electrical Installation	IS 5572, IS 5571
Electrical apparatus for explosive gas atmospheres-General Requirements	IEC 60079
Fault level calculation	IS: 2026

B. Constructional Features

a) Switchgear design shall be of metal enclosed, single front, free standing, floor mounted and fully compartmental execution having separate sections for each circuit. Each Circuit shall have a separate vertical panel with distinct compartments for main bus bars, circuit breaker, cable termination and auxiliary devices.

b) The adjacent panels shall be completely separated by steel sheets except in bus bar sheet compartments where insulated barriers shall be provided to segregate adjacent panels. Compartments with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuits.

c) Switchgear cubicle shall be provided with hinged door on the front with facility for locking door handle.

d) Switchboard shall be dust and vermin-proof and shall have a degree of protection of enclosure of IP 4X and the relay and meter compartments shall have a degree of Protection not less than IP 52.

e) All removable covers shall be gasketed all around with neoprene or superior gaskets.

f) Instruments, relays and control devices shall be flush-mounted on hinged door of the metering compartment located in the front portion of cubicle. The metering compartment shall be properly shielded to prevent mal-operation of electronic equipment such as numerical / static relays due to electro-magnetic fields.

g) All transformers shall be provided with alarm annunciation on breaker control panel.

h) Each switchgear cubicle shall be fitted with a label on the front and rear of the cubicle. Each switchboard shall also be fitted with label indicating the switchboard designation, rating and duty.

i) Each relay, instrument, switch, fuse and other devices shall be provided with separate label.

j) The fully draw-out modules shall have all the circuit components mounted on withdraw able type steel chassis.

k) All power and control connections shall be of the draw out type. It shall be possible to withdraw the chassis mounted circuit components without disconnecting any connections. All draw-out contacts shall be of silver plated copper.

l) In case of circuit breaker compartments, suitable barriers shall be provided between breaker and all control, protective and indication circuit equipment including instrument transformers such that no live parts are accessible.

m) External cable connections shall be through separate cable compartments for power and control cables. Safety shutters shall be

provided to cover up the fixed high voltage contacts on busbars when the circuit breaker carriage is moved to' test' and 'isolated' positions.

n) One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal busbar compartment. However, each shipping section shall have metal sheets at both ends. After isolation of the power and control connections of a circuit, it shall be possible to carry out maintenance in a compartment safely, with the bus bars and adjacent circuits alive.

o) All sheet steel work shall be phosphate in accordance with the following procedure and in accordance with IS: 6005 "Code of Practice for Phosphate Iron and Steel".Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning.Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

p) After phosphate, thorough rinsing shall be clean water followed by final rinsing with dilute dichromate solution and even drying.The phosphate coating shall be followed by the application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests.The final finished thickness of paint film on steel shall not be less than 100 microns and shall not be more than 150 microns. Finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surface.A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

C. <u>Circuit Breaker</u>

a) Circuit breakers shall be vacuum type with three separate single pole interrupting units, operated through a common shaft by a sturdy operating mechanism. Surge Arrestors shall be provided for each motor / transformer feeder.

b) Circuit Breakers shall be re strike free, stored energy operated and trip free type. Circuit breaker along with its operating mechanism shall be mounted on a wheeled carriage moving on guides, designed to align correctly and allow easy movement. Plugs and sockets for power circuits shall be silver faced and shall be insulated with suitable insulating material shrouds. All corresponding components of circuit breaker cubicles of same rating shall be interchangeable with one another.

c) Anti pumping relay and trip coil suspension relay shall be provided.

d) There shall be ‘Service’, ‘Test’ ‘Fully withdrawn’ positions for the breakers. In the ‘Test’ position the circuit breaker shall be capable of being tested for operation without energizing the power circuits, i.e. the control circuits shall remain undisturbed while the power contacts shall remain disconnected.

e) Separate limit switches, each having a minimum of 2 ‘NO’ + 2 ‘NC’ contacts, shall be provided for both ‘Service’ and ‘Test’ positions of the circuit breakers. All these service, test, fully withdrawn, spring charge and also breaker ON / OFF shall be visible mechanically from outside the breaker panel when the front door is closed.

f) Electrical closing & tripping shall be performed by shunt trip & close coils both in Local & Remote mode. Selector switch lockable in “Local” position shall be provided on the cubicle door. ‘Red’ and ‘Green’ indicating lamps shall be provided on cubicle door to indicate breaker close and open positions. Breaker “Service”, “Test” and breaker readiness positions shall be indicated by separate indicating lamps on the cubicle door.

g) Connection of the control / interlocking circuits between the fixed portion of the cubicle and the breaker carriage shall be preferably by means of plug socket arrangement.

h) 10% spare feeders with at least one for each type of highest rating shall be provided in each switch gear.

i) Surge arrestors shall be provided for all motors / transformer feeders and shall be metal oxide gapped or gapless type generally in accordance with IEC 60099-1and suitable for indoor only.

j) Core balance CTs (CBCT) shall be provided on outgoing motor and transformer feeders having CT Ratio 50 / 1A or more. These CBCTs shall be mounted inside the switch gear panel.

D. <u>Operating Mechanism Control</u>

a) Circuit breakers shall be operated by a motor spring charging type of mechanism. The mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.

b) Operating mechanism shall normally be operated from the breaker cubicle itself.

c) The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

d) Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.

e) The circuit breaker mechanism shall make one complete closing operation, once the push button (PB) or control switch has been operated and the first device in the control scheme has responded, even though the PB or control switch is released before the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.

f) Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall also be provided on the operating mechanism.

g) Circuit breaker control shall be on 110 V DC. Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 80-110 % of the control voltage. Trip coils shall operate satisfactorily between 50 -110 % the rated control voltage.

E. <u>Safety Interlocks and Features</u>

a) Withdrawal or engagement of a circuit breaker shall not be possible unless it is in the open position.

b) All circuit breaker shall have lockable local / remote selector switch, for closing the breaker from local shall be possible only in TEST position. Whereas as closing from remote shall be possible in either SERVICE and TEST position. For opening breaker from local shall be possible only when local remote selector switch shall be in local position. Opening breaker from remote shall be either breaker in service position or selector switch being in remote position.

c) All Motors and Service Transformers feeder breaker shall have lockable emergency push button (openable only with key) near motor and service transformer, hard wired to circuit breaker panel emergency push button.

d) Operation of a circuit breaker shall not be possible unless it is in service position, withdrawn to test position or fully drawn out. It shall not be possible to close the circuit breaker electrically in the service position, without completing the auxiliary circuit between the fixed and moving portions.

e) Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the stationary isolated contacts when the breaker is withdrawn. Padlocking facilities shall be provided for locking the shutters positively in the closed position. It shall, however, be possible to open the shutters intentionally against spring pressure for testing purposes.

f) The circuit breaker carriage shall be earthed before the breaker reaches the test position from fully withdrawn position. In case of breakers with automatic disconnecting type of auxiliary disconnects, the carriage shall be earthed before the auxiliary disconnects are made and the carriage earthing shall break only after the auxiliary disconnects break.

g) Caution nameplate, “Caution Live Terminals” shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, i.e. incomer to the switchboard. Suitable interlock shall be wired for the purpose.

F. <u>Earthing</u>

a) Copper earthing bus shall be provided and extended throughout the length of the switchboard. It shall be bolted to the framework of each unit and brazed to each breaker earthing contact bar. It shall be located at the bottom of the board.

b) The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current for at least 1 second or higher without exceeding maximum allowable temperature rise.

c) The earth bus shall be properly supported to withstand stresses induced by the momentary short circuit current.

d) Suitable clamp type terminals at each end of the earth bus shall be provided to suit the size of the earthing conductors. Bolted joints, slices, tap, etc. to the earth bus shall be made with at least two bolts. Positive earthing of circuit breaker frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

e) Hinged doors shall be earthed through flexible earthing braid of adequate cross section.

f) All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus.

g) Positive connection of the frames of all the equipment mounted in the switchboard to the earth bus bar shall be maintained through insulated conductors of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller.

h) All instrument and relay cases shall be connected to earth busbar by means of 1100V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through each of the earth terminals.

G. <u>Circuit / BusbarEarthing Facility</u>

a) It shall be possible to connect each circuit or set of 3 phase bus bars of the switchboard to earth through earthing switches.

b) Earthing switches / earthing devices shall be mechanically interlocked with the associated breakers to prevent accidental earthing of live circuit or bus bars. In case the earthing facility comprises earthing trucks to be inserted in place of circuit breakers, separate earthing trucks shall be supplied for each type / size of breaker.

c) The earthing facilities proposed to be provided by the Bidder shall be clearly detailed in the Bid and shall be subject to Employer's approval. Auxiliary contacts (min. 2 NO + 2 NC) shall be provided on each earth switch / earthing device and shall be wired to the terminal block for interlocking purpose.

H. Annunciators

a) Annunciators shall be of fascia type with translucent plastic window for each alarm point.

b) Annunciated fascia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective fascia LED light is lighted.

c) Each annunciation window shall be provided with two LED Lights to provide redundancy against LED light failure. Lamps shall be replaceable from the front. Lamps shall be of clustered LED type.

d) All fascia annunciated points shall be suitable to accept external contacts of either 'NO' or 'NC' self or hand reset type for initiating the annunciation sequence shall be suitable for accepting fleeting faults of duration as less as 15 milliseconds.

e) For static Annunciator schemes, special precaution shall be taken by the Contractor to ensure that spurious alarm conditions do not appear due toinfluence of external magnetic fields on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels / desks.

f) A "Lamp Test" push button shall be provided for each individual panel's group of Annunciators to limit the sudden drain on the battery. Provision of testing facilities for flasher and audible electronics alarm circuits of annunciators is desirable. The Contractor shall give the details of the offered scheme.

g) Annunciator shall have following features:

- Suitable for annunciating subsequent faults immediately after the sound cancel of the previous fault.
- During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the "lamp test" circuit and shall start flashing.

- Designed to prevent mal-operation of the scheme or sequence when the push buttons are pressed incorrectly or in the wrong order.
- "Alarm Supply Failure" Alarm scheme similar to the normal annunciation sequence, but shall operate on a different DC supply or on AC auxiliary supply
- Alarm annunciates having provision to integrate all alarm / trip signals to PLC.
- Alarm annunciation shall be provided for transformers, Chlorination system and surge vessel system where ever discrete local automation is envisaged.
- All Annunciations shall have interfacing facilities for communication for SCADA.

I. Indicating Instruments & Meters

a) The instruments shall be electronic / digital type with LCD display. These instruments should have high performance ratio and can be equipped with digital output (for alarms) or with interfacing facilities for communication and remote reading of parameters.

Metering Instruments

- Multi Function Meter (MFM) with the facility to measure A, V, KW, KWh, KVAr, PF, Hz with communication port.
- Multi-Function Meters shall be of the accuracy class 1.0, suitable for measurement of unbalanced loads in three phase three wire circuits.

b) MFM shall be suitable for operation from the secondary of CTs and VTs. They shall be provided with a separate 3 phase 4 wire type test blocks for the testing of the meters without disturbing the CT and VT secondary connections.

c) The instruments can be electronic / digital type with LCD display & RS 485 connectivity for remote reading of parameters in SCADA. These instruments should have high performance ratio and can be equipped with digital output (for alarms).

J. Control and Selector Switches

a) Control and instrument switches shall be heavy duty rotary type, provided with escutcheon plates clearly marked to show operating position and suitable for semi-flush mounting with only the switch front plate and operating handle projecting out. The connections shall be from the back. The contact assembly at the back of the switch shall be enclosed in dust tight removable covers.

b) The control switches shall be 3 positions, spring return to neutral type. They shall be provided with contacts to close in ‘normal after close’ and ‘normal after trip’ position.

c) Each switch shall have external red and green indicating lamps, (except when discrepancy type switches are called for). In addition, a semaphore indicator shall be provided for earthing switch.Local / Remote selector switch shall be stay put 2 /3 position with lockable provision.

d) Contacts of the switches shall be spring assisted and contact faces shall be of silver / silver alloy. Springs shall not be used as current carrying parts. Contact rating and configurations of the switches shall be adequate for the functions desired.Lockable type switches, which can be locked in a particular position, shall be provided, if required. Emergency stop buttons, if any, shall incorporate ‘stay-put’ features with independent reset facilities.

K. <u>Indicating Lights / Pilot Lights</u>

a) Indicating light shall be rated for operation at either 230 V AC or at the specified DC system voltage as applicable. Lights shall be provided with translucent light covers.

b) Clustered LED type lamps shall be provided. Lenses shall be glass or plastic in standard colours, red, green, blue, white and amber, in accordance with IEC 60073. Miniature pilot lamps may be provided with plastic marking plate contained inside square (or rectangular) front lens to provide indication of legend or symbols engraved on the marking plate.

c) The basis of colours shall be as follows:

Red : Flow of energy.

Green : No flow of energy.

White : Supervision of power available, relay coil healthy, etc.

Amber : For all alarm conditions such as pressure low, overload, Disagreement with original condition, ‘abnormal’ condition or ‘sequence–on’ condition also for service and test position.

Blue : For all healthy conditions such as control supply, spring charged and lockout relay coil healthy.

Yellow : For R, Y, B indication light, yellow as one of the light.

L. Push Buttons

a) Push buttons shall be of momentary contact type with rear terminal connections. The colour of the push button actuator shall be red for ‘OPEN / STOP’ and green for ‘CLOSE / START’. The push button knob shall be suitably shrouded to prevent inadvertent operation. The push buttons shall be provided with integral inscription plates engraved with their designation.

b) Normal stop push button shall be mushroom type latchable in red colour, after pressing andit is latched, the latch can be removed by clockwise rotation. (Motor stops automatically after pre determined conditions such as delivery valve close in case of pumps.) This may replace stop push button.

c) Emergency stop push button red in colour shall be lockable by pressing the push button and can be opening only with key and with shrouding. (Motor stopped immediately irrespective of predetermined conditions required)Emergency Push button with shrouding shall be provided near transformer and motors for remote tripping.

d) Reset push button shall be either for resetting the flag and OLR or LEDs with push button for resetting.

e) All push buttons shall have independent, potential free, 2NO + 2NC contacts. The contact faces shall be of silver / silver alloy. The contacts shall be rated 10A and capable of breaking inductive load of 5A at 110V DC.

f) All push button shall have additional NO /NC potential free for hard wiring to instrumentation control panel.

M. Space Heaters

Adequately rated anti-condensation space heaters shall be provided for each switchboard / cubicle, bus ducts and Motors above 30 kW. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system. Space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a RTD thermostat to cut off the heaters at 35 degree C.

N. Cubicle Lighting / Receptacle

Each cubicle shall be provided with interior lighting by means of 18 W energy efficient (lumen per watt shall be indicated) fluorescent tube lighting fixture. An MCB shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 240 V, 1 ph, 50 Hz, AC supply. A 240 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with an MCB.

O. Power and Control Cable Termination

a) Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable aluminium solder less crimping type of lugs for terminating the cables and control cables lugs and ferrules shall be tinned copper confirming to IS 8309. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of termination provide on the equipment.

b) Double compression type glands with armour and bonding clamps for the termination of all solid dielectric multicore cables shall be provided and shall confirm to BS: 6121. They shall be designed to secure the armour wires to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between the cable outer sheath and gland and between the inner sheath and threaded fixing component. The gland shall preferably project above the gland plate to avoid entry of moisture.

c) Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding test for appropriate high voltage for one minute.

d) Cable terminations for HV / MV cables shall be heat / cold shrinkable type. Adequately sized shrouds / bolts shall be provided at connections to completely cover the terminations.

e) Where core-balance type current transformers are provided on the feeder cables for earth fault protection, glands for cables shall be insulated from earth in an approved manner.

P. Wiring For Control and Protective Circuits

a) All low voltage wiring for control, protection and indication circuits shall be carried out with 1100 V grade, PVC insulated cable with stranded, tinned copper conductor of minimum 1.5 sq. mm size. The size of conductor for CT circuits shall be minimum 2.5 sq. mm.

b) All wiring shall be run on the sides of panels and shall be neatly bunched and cleated without affecting access to equipment mounted in the panel. The wiring shall be bound and supported by clamping, roughing or lacing. Spiral wrapping will not be accepted. Wire ways shall not be more than 50% full. Adequate slack wire shall be provided to allow for one re-stripping and reconnection at the end of each wire. When screened cables or wires are necessary, an insulating sheath shall be included. Wiring and supports shall be of fire resistant material.

c) Wiring shall only be jointed or tied at terminals. Terminals of the clamp type shall not have more than two wires connected.

Q. Termination and Ferrules

a) Engraved core identification ferrules, marked to correspond with the wiring diagram, shall be fitted to each wire and each core of multicore cables terminated on the panels.

b) Moisture and oil resisting insulating material shall be used. The ferrules shall be of the interlocking type and shall grip the insulation firmly without falling off when the wire is removed.

c) All wires forming part of a tripping circuit shall be distinctively marked. Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

R. Control Wiring Terminal Blocks

a) Terminal blocks (TBs) shall be of 1000 V grade, 10A and stud type. Brass stud of at least 6 mm dia. with fine threads shall be used and securely locked within the mounting base to prevent turning. Each terminal shall comprise two threaded studs, with a link between them, washers, and matching nuts and locknuts for each stud. Connections to the terminals shall be at the front.

b) Terminals shall be numbered for identification, grouped according to function. Engraved ‘black on-white’ labels shall be provided on the terminal blocks describing the function of the circuit.

c) Terminals for circuits with voltage exceeding 110 V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled. Terminals used for connecting current transformer secondary leads shall be ‘disconnecting and shorting’ type with a facility for earthing the secondary.

d) Terminal blocks shall be arranged with 100 mm clearance, between any two sets. Separate terminal stems shall be provided for internal and external wiring respectively. All wiring shall be terminated on terminal blocks, using crimping type lugs or claw type of terminations.

e) At least 20 % cores shall be kept spare in multicore control cables. At least 10% spare terminals shall be provided and space for adding another 10% spares terminals shall also available in each set of TBs.

S. Bus Bars

a) The Bus bars shall be of electrical grade, high conductivity, copper and shall be provided with minimum clearances as per relevant IS. Bus bar cross section shall be uniform throughout the length of the switchgear.

b) All bus bars and bus taps shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self-extinguishing type and in fast colours to indicate phases.

c) The dielectric strength and properties shall hold good for the temperature range of 0 to 95 degree centigrade. If the insulating sleeve is not coloured, bus bars shall be colour coded with coloured PVC tape at suitable intervals.

d) Busbar joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at the joints. Busbars shall be thoroughly cleaned at the joints and suitable contact grease shall be applied just before making a joint.

e) Direct access to, or accidental contact with busbars and primary connections shall not be possible. All apertures and slots shall be protected by baffles to prevent accidental shorting of busbars due to insertion of maintenance tools.

f) Sequence of red, yellow and blue phases and neutral for four-pole equipment shall be left to right and top to bottom, for horizontal and vertical layouts respectively.

g) End terminations at transformer end and MV panel end shall be flexible bus bar such that no load / force / weight of the bus bar act on the terminal studs.

T. Current & Voltage Transformers

a) Current transformers shall be of cast resin, bar-primary type unless specified otherwise, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure and shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block. The class of insulation shall be Class E or better.

b) Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear. For wound-primary type CTs, the short time current rating shall not be less than 0.5 sec. CT core laminations shall be of high grade silicon steel. Where multi-ratio current transformers are specified, a label shall be provided, clearly indicating the connections required for the alternative ratios.

c) These connections shall also be shown on panel wiring diagrams. Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels are to be fitted on the exterior of the mounting chambers suitably located to enable reading without the removal of any cover or metal sheeting forming part of the structure of the switchboard.

d) Magnetization characteristics, calculated performance and protective settings shall be provided by the Contractor. All Voltage Transformers shall be of Single Phase type. The bus VT’s shall be housed in a separate panel in a truck so as to be fully with draw able. All Voltage transformers shall have HRC fuses on Primary and Secondary Side. There shall be provision for changeover on secondary side of Voltage Transformers to have alternate arrangement in case one Voltage Transformer fails.

U. Relays

(i) All Protective relays shall be numerical type. Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity.

(ii) All numerical protective relays shall be flush mounted at the front with connections at the rear. Shall have communication port for remote, metering and monitoring facility, suitable for electrical measurement

including voltage, current, power (active / reactive) and energy parameters.

(iii) All numerical relays shall have keypad to allow relay settings from relay front. Resetting knobs shall be accessible from the front on removing the external cover and shall be external to the case.

(iv) All numerical relays and timers shall be rated for control supply voltage specified and be capable of satisfactory continuous operation between 70 % and 110 % of the rated voltage. Making, Carrying and Breaking Current ratings of the relay Contacts shall be adequate for the circuits in which they are used.

(v) The numerical relays shall have communication, Metering and Monitoring Facility. The communication facility shall have two Ports local front port(RJ45/USB) for laptop communication and the second port(Rear RS485) for SCADA.

(vi) The numerical processor shall be capable of measuring and sharing values of a wide range of quantities, events, faults and disturbance recordings with time stamping using internal real time clock. Battery backup for real time clock in the event of power failure shall be provided.

(vii) Numerical Relays shall have diagnostic feature with self check for power failure, Programmable routines, memory and main CPU Failures etc.

(viii) The Protective relays shall have adequate number of potential free contacts (Programmable). The Contacts shall be suitable for directly wiring in the breaker closing and tripping circuits operating from 110 V DC Control Voltage.

(ix) The current operated relays shall have provision for 4 Sets of CT Inputs and Voltage operated relays shall have provision for 3 PT inputs. Relays shall be suitable for CT secondary current suitable for CT Secondary current of 1 A / 5 A selectable at Site.

(x) Numerical Relays shall be immune to any kind of electromagnetic interference and capacitance effect due to length of connected control cables.

(xi) Timer function shall be programmable for ON/OFF delays.

(xii) Numerical Relays shall be able to provide supervisory function such as trip circuit monitoring, circuit breaker monitoring, PT & CT supervisions and recording facilities with post fault analysis.

(xiii) All relays shall withstand minimum test voltage of 2 KV AC RMS for one minute.

(xiv) Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.

V. Energy monitoring and power supply management

a) Necessary Provisions & features shall be incorporated to enable energy monitoring /energy management for the installation. Energy Metering shall meet the requirement of guaranteed specific energy consumption specified by the contractor through instrumentation control system.

b) In case, Numerical relays having built in features of energy measurement of requisite accuracy and provided in switch gear, separate energy meter is not required.

c) Necessary provision & features shall be incorporated to under voltage monitoring/ relay for incomer feeder, bus bar chamber and control supply.

W. I / O signal for Instrumentation, Control & Automation System from Electrical panels.

a) I/O signals from instruments shall be separately wired to a marshalling box such that instrumentation engineers will not enter in to power panel that are not familiar with them.

b) Necessary provisions shall be incorporated to meet the requirements indicated in

(i) I/O Schedules – ACB/VCB, Command Open &Close, Feedback trip, Breaker healthy (Ready to close), Local /Remote, Breaker Opened / Closed.

(ii) Data Transfer Schedule

(iii) Alarm Schedule of Particular requirement of Instrumentation, Control & Automation System, Part-13, and Volume 2 of the Bid document.

X. Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates etc. shall be submitted along with the bid/ after award of contract as specified under " Bid/Contract Drawings" , Part 3, General Requirements, Volume-2 of Bid Documents.

15.2 NEUTRAL SOFT START PANEL

A. Applicable Standards

The design, manufacture and performance of equipment shall conform to the latest standards specified below.

Switchgear General Requirements (All parts)	IS/IEC:60947 / BS:5486 / IEC:60947
Factory Built Assemblies of SWGR and Control gear for Voltages up to and including 1000V AC & 1200V DC	IS/IEC 61439/ BS:5486 / IEC:61439
Air Break Switches	IS/IEC:60947 / BSEN60947 / IEC:60947-3
Moulded Case Circuit Breaker	IS 2516 / IEC 60947-2 / BS EN 60947-2
Miniature Circuit Breakers	IS:8828 / BSEN:60898
Low voltage Fuses	IS:13703 / BS:1362 / IEC:60269-1
Contactors	IS/IEC:60947 / BS EN60947-4 / IEC:60947-1
Starters	IS/IEC:60947 / BS EN60947-4 / IEC:60292-1 to 4
Control Switches / Push buttons	IS:6875 / BSEN 60947
Instrument Transformers	IS 16227 / IEC 61869 / IS/IEC 60044
Indicating instruments	IS:1248 / BS:89 / IEC:60051
Marking and Identification of Conductors and Apparatus Terminals	IS:11353 / BS:159
A.C. Electricity Meters	IS:722, 8530 /BS:5685 / IEC 60145,60 211
Degree of Protection	IS/IEC:60947 / IEC:60947-P1
Selection installation and maintenance of switchgear and control gear	IS:10118

Code of practice for phosphating coated iron and steel	IS:6005 / BS:3189
Specification for copper rods and bars for electrical purposes	IS:613
Control transformers for switchgear and control gear voltage not exceeding 1000V AC	IS:12021
Classification of Hazardous areas having Flammable gases and vapours for Electrical Installation	IS:5572
Explosive Atmospheres-Electrical Installations Design, Selection and Erection	IS 16724: 2018
Electrical apparatus for explosive gas atmospheres-General Requirements	IEC:60079

B. Constructional and Performance Features

(a) Neutral soft start panel shall be indoor, metal clad with separate metal enclosed compartments for (i) control, metering and current transformers for differential protection (ii) shorting switch (iii) busbars (iv) power cable terminations (v) push buttons with indicating lamps.

(b) Starter shall achieve smooth starting by torque control for gradual acceleration of the drive system thus preventing jerks and extending the life of equipment.

(c) Starting current shall be limited to 3.0 times the full load current of the motor.

(d) Separate removable gland plates shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.

(e) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphated and then painted with two coats of zinc rich primer plant. After application of the primer, two coats of finishing synthetic enamel paint oven baked/ stoved, shall be applied.

(f) The cable compartment shall house all power cable connections along with associated cable terminations.

(g) Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

(h) Caution name plate with inscription “Caution - Live Terminals” shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, e.g. incoming terminals of main disconnecting switch.

(i) Starting of motor shall be from either soft starter panel located near to motor or shall be from motor modules or from PLC. Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

C. Main Busbars

(a) Busbars shall be fully insulated by encapsulation in epoxy resin, with moulded caps protecting all joints.

(b) Busbars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit.

(c) Busbars shall be of copper conductor of hand drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.

D. Earthing

(a) An earthing bus shall be provided at the bottom and extended throughout the length of the panel. It shall be bolted/welded to the frame work.

(b) All non-current carrying metal work of the panel shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

E. Panel Accessories and Wiring

(a) Panel shall be supplied completely wired internally upto equipment and terminal blocks and ready for the external cable connections at the terminal blocks. Inter panel wiring between compartment of the same panel shall be provided.

(b) All auxiliary wiring shall be carried out with 650 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 mm^2.

(c) Terminal blocks shall be of stud type, 650 volts grade 10 amps rated, complete with insulated barriers. Terminal blocks for CTs shall be provided with test links and isolating facilities.

(d) All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.

(e) Accuracy class for indicating instruments shall be 2.0 or better. Instruments shall be 110 mm square, 240° scale for flush mounting with only flanges projecting.

(f) Relays shall be suitable for flush mounting with only flanges projecting.

(g) All protective relays shall be in draw-out cases with built-in test facilities. Necessary test plugs shall be supplied loose and shall be included. All auxiliary relays and timers shall be supplied in non-draw-out cases. Externally operated hand reset flow indicators shall be provided on all relays and timers. Timers shall be of electromagnetic or electronic type only.

(h) Push buttons shall be provided with inscription plates engraved with their functions.

(i) Indicating lamps shall be panel mounting type with series resistors. The wattage of lamps shall be 5 to 10 watts.

(j) Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 240 V, 1 ph, 50 Hz supply. They shall be complete with HRC fuses, isolating switches and thermostat.

(k) Each panel shall be provided with 240 Volts, 1 phase, 50 Hz, 5 amps, 3 pin receptacle with switch located in a convenient position. An interior illuminating lamp together with the operating door switch and protective fuses shall be provided.

(l) Provision shall be made for receiving, distribution, isolating and fusing of auxiliary D.C. and A.C. supplies for controls, space heating etc. The fuse ratings shall be so chosen as to ensure selective clearance of subcircuit faults.

(m) Fuses shall be HRC cartridge type mounted on plug in type fuse base.

(n) The D.C. and A.C. auxiliary supply shall be distributed inside the panel with necessary isolating arrangements at the point of entry and with sub-circuit fuses as required.

F. Cable Termination

(a) Necessary number of cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring etc.

(b) Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper/aluminium depending on cable conductor and of solderless crimping type

(c) All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armour clamps, brass glands etc. shall be supplied.

G. Drawings and Data

All Drawings, data, technical particulars ,calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified " Tender/Contract Drawings" , Part 3, General Requirements, Volume-2 of tenderdocuments.

15.3 415 V METAL ENCLOSED SWITCHGEARS / MCC

A. Applicable Standards

The switchgear and its components shall conform to the latest applicable standards specified below. .

Low-Voltage Switchgear and Control gear (All Parts)	IS/IEC 60947 / BS:5486 / IEC:60947
Low-voltage Switchgear and Control gear assemblies (All Parts)	IS/IEC:61439
Moulded Case Circuit Breaker	IS:2516 / IEC 60947-2 / BS EN:60947-2 / IS/IEC 60947
Miniature Circuit Breakers	IS:8828 / BSEN:60898
Low voltage Fuses	IS:13703 / BS:1362 / IEC:60269 - 1
Contactors	IS/IEC :60947 / BS EN60947 - 4 / IEC:60947 - 1
Starters	IS/IEC:60947 / BS EN60947 – 4 /

	IEC:60292 -1 to 4
Control Switches / Push buttons	IS:6875 / BSEN 60947
Instrument Transformers	IS 16227 / IEC 61869 / IS/IEC 60044
Indicating instruments	IS:1248 / BS:89 / IEC:60051
Electrical relays.	IEC:60255
Marking and Identification of Conductors and Apparatus Terminals	IS:11353/BS:159
A.C. Electricity Meters	IS:722, 8530 / BS:5685 / IEC:60145, 60211
Degree of Protection	IS/IEC: 60947 / IEC:60947
Selection installation and maintenance of switchgear and control gear	IS:10118
Code of practice for phosphating coated iron and steel	IS:6005 / BS:3189
Specification for copper rods and bars for electrical purposes	IS:613
Control transformers for switchgear and control gear voltage not exceeding 1000V AC	IS:12021
Classification of Hazardous areas having Flammable gases and vapours for Electrical Installation	IS:5572
Explosive Atmospheres-Electrical Installations Design, Selection and Erection	IS 16724: 2018
Electrical apparatus for explosive gas atmospheres-General Requirements	IEC:60079
Basic and Safety Principles for Man-Machine Interface, Marking and Identification - Coding Principles for Indicators and Actuators.	IEC:60073
Conductors of Insulated Cables.	IEC:60228
Dimensions of low-voltage switchgear and Control gear. Standardized mounting on rails for mechanical support of electrical devices in switchgear and Control gear installations.	IEC 60715
Graphical symbols for use on equipment.	IEC:60417
Electricity metering equipment	IEC:62052-11 / IEC 62052 - 21
Empty enclosures for low-voltage switchgear and Controlgear assemblies General requirements and Control gear assemblies General Requirements	IEC:62208

B. Features of Construction

(a) The switchgear shall be metal enclosed, dust proof, modular type, suitable for indoor floor mounting and shall have following features.

(i) Total height of switchgear shall not exceed 2300 mm. Height of Switches,
Pushbuttons shall not exceed 1800 mm and shall not be less than 700 mm.

(ii) Shall be single front execution and fixed type

(iii) Shall have designation labels both on front and rear sides

(iv) Shall be provided with proper gasketing for removable covers, doors, between panels and base frame and all around the perimeter of adjacent panels.

(v) Degree of Protection shall be IP54.

(vi) Thickness of CRCA Sheet is 2mm.

(b) Switchgear shall be divided into distinct vertical sections each comprising :

(i) A completely enclosed busbar compartment running horizontally

(ii) Enclosed vertical busbars serving all modules in vertical section

(iii) A separate horizontal enclosure for all auxiliary power and control buses if required

(iv) Vertical cable alley of 250mm wide covering entire height

(c) Operating devices shall be incorporated only in the front of switchgear.

(d) Each shipping section shall have metal sheets at both ends.

(e) Cable alley shall be provided with suitable hinged doors.

(f) GS/GIEarth bus of size 50mm x 10 mm shall be provided at the bottom.

(g) Rear of Single Front Switchgear shall be provided with removable panels with screws.

(h) All doors shall be with concealed type hinges and captive screws.

(i) Each vertical section shall be equipped with 240 V, 1 Phase, 50 Hz space heater controlled by thermostat.

(j) A 240 V, 1 phase, AC plug point shall be provided in the interior of each cubicle with on-off switch for correction of head lamps.

(k) Interchangeability

All identical equipment and corresponding parts be fully interchangeable without any modifications.

(l) Main and Auxiliary Buses

(i) Switchgear busbars shall be of uniform cross section throughout the length and made of high conductivity, electrical grade hard drawn copper conductor.

(ii) Busbar shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints and shall be adequately supported to withstand stresses developed due to short circuits. Supports shall be of glass reinforced phenolic material or cast resin.

(iii) Busbar joints shall be provided with contact grease at the joints and shall be complete with tensile steel bolts and Belleville washers and nuts.

C. Air Circuit Breaker (ACB)

(a) Air circuit breaker shall be selected for feeders for load current equal to and more than 630A.

(b) Circuit breakers shall be operated by a motor spring charging type of mechanism. The motor operated spring charged mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.

(c) The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

(d) Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.

(e) The circuit breaker mechanism shall make one complete closing operation, once the push button has been operated and the first device in the control scheme has responded, even though the PB is released before

the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.

(f) Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall be provided on the operating mechanism.

(g) All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication.

(h) Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85-110 % of the control voltage. Trip coils shall operate satisfactorily between 70 -110 % the rated control voltage.

(i) The Breaker shall be provided with Microprocessor based releases for Inverse-time delayed overload releases for the phases, Short-time delayed short-circuit releases and earth-fault releases.

(j) The breaker service Short Circuit breaking capacity (ICS) shall be equal to ultimate Short Circuit capacity (ICU)and shall be equal to short time withstand current of Breaker (ICW)

D. Moulded Case Circuit Breaker (MCCB)

(i) MCCBs shall be of the air break, quick make, quick break and trip free type and shall be totally enclosed in a heat resistant, moulded, insulating material housing.MCCBs shall have an ultimate short circuit capacity not less than the short circuit current Specified .MCCBs shall have a service short circuit breaking capacity (I_{CS}) equal to the ultimate short-circuit capacity (I_{CU}).

(ii) Each pole of MCCB shall be fitted with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short circuit protection. Alternatively, they shall be fitted with a solid state protection system. Such a protection system shall be fully self-contained, needing no separate power supply to operate the circuit breaker tripping mechanism. Thermal element shall be adjustable. Adjustments shall be made simultaneously on all poles from a common facility. Thermal elements shall be ambient temperature compensated.

(iii) The MCCBs shall be provided with the following features.

(i) Common trip bar for simultaneous tripping of all poles

(ii) Shrouded terminals

(iii) Time for clearing short circuit current of 20 msec.

(iv) 2 NO + 2 NC auxiliary contacts

E. Switches and Fuses

(a) 415 V air-break switched shall be of the load break, fault make, group operated type. For use on 3-phase systems, the switches shall be of the triple pole type with a link for neutral wire. For use on single phase system and d-c systems, the switches shall be of the two pole type.

(b) Switches shall be of the heavy duty, quick make and quick break type. Switch contacts shall be silver plated, and contract springs shall be of stainless steel. Switch handles shall have provision for locking in both fully open and fully closed positions. Mechanical ON-OFF indication shall be provided on the switches.

(c) Switches for controlling motor circuits shall be of the load break, fault make type, and shall be capable of breaking locked rotor current of the associated motor.

(d) 415 V switches and fuses shall be provided with the following interlocks so that :

(e) The fuses are not accessible unless the switch is in fully open condition.

(f) It is not possible to close the switch when the fuse cover is open, but an authorised person may override the interlock and operate the switch. After such an operation, the cover shall be prevented from closing if the switch is left in the 'ON' position.

(g) All fuses shall be of the HRC cartridge type, mounted on plug-in type of fuse bases. Fuses shall be provided with visible indicators to show that they have operated.

(h) Earthing and neutral lines in main supply circuits shall be of solid silver plated copper and be of the bolted pattern.

(i) Fuses and links functionally associated with the same circuit shall be mounted side by side.

F. Miniature Circuit Breaker (MCB)

(a) MCB shall be hand operated, air break, quick make, quick break type.

(b) Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

(c) Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the connected load. Where this is not specified, it shall be Type C. The short circuit rating shall be not less than that of the system to which they are connected.

G. Contactors

(a) The power contactors used in the switchboard shall be of, air break, single throw, triple pole, electromagnetic type. Contactors shall be suitable for uninterrupted duty and rated for Class AC3 duty in accordance with the latest edition of IS 13947.

(b) Operating coils of all contactors shall be suitable for operation on 240 V, single phase, 50 Hz supply. Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts. Contactors shall not drop out at voltages down to 70 % of coil rated voltage. Contactors shall be provided with a three element, positive acting, ambient temperature compensated, time lagged, hand reset type thermal overload relay with adjustable settings. The hand reset button shall be flush with the front door of the control module, and shall be suitable for resetting the overload relay with

the module door closed. Relays shall be either direct connected or CT operated. Overload relay and reset button shall be independent of the "Start" and "Stop" push buttons. All contactor shall all be provided with single phasing preventer (SPP).

(c) Motor starters shall be complete with auxiliary relays, timers and necessary indications.

H. Current Transformers

(a) Current Transformers shall be Cast Resin type.

(b) Current transformers shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block.

(c) Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear, as indicated in the Technical Specification.

(d) CT core laminations shall be of high grade silicon steel.

(e) Identification labels shall be fitted giving type, ratio, rating, output and serial numbers.

I. Voltage Transformers

(a) Voltage Transformers shall be Cast Resin type.

(b) Secondary and tertiary windings of voltage transformers shall be rated for a three phase line to line voltage of 110 V.

(c) It shall be possible to replace voltage transformer fuses easily without having to deenergiser the main bus-bars.

J. Indicating Instruments & Meters

(a) Electrical indicating instruments shall be 110 mm square with 240º scale. Taut band type of instruments is preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers.Instrument dials shall be white with black numbers and lettering.

(b) Normal maximum meter reading shall be of the order of 60 % normal full scale deflection. Ammeters for motor feeders shall have suppressed scale

to show current from full load up to six times the full load current.Watt hour meters shall be of the induction type and shall be provided with reverse running stops. Instruments shall have an accuracy of Class 1.0.

K. Indicating Lamps

Indicating lamps shall be of the cluster LED type, with low watt consumption. Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 240 V AC or at the specified DC system voltage as applicable. Lamps shall be provided with translucent lamp covers.Bulbs and lenses shall be interchangeable and easily replaceable from the front.

L. Push Buttons

"Start" and "Stop" push buttons shall be coloured green and red respectively. Stop Push Button shall be lockable stay-put type with Mushroom head.

M. Space Heaters

Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk.Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system. Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control thermostat to cut off the heaters at 350 ^{0}C.

N. Safety Arrangements

All terminals, connections and other components, which may be “live” when front access door is open, shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle or module when any door is opened. Components within the cubicles shall be labelled to facilitate testing.

O. Earthing of Switchboards / Panels

(a) Each switchboard, control panel, etc. shall be provided with an earth busbar running along its entire length. The earth bus bar shall be located at the bottom of the board/panel.

(b) Earth bus bars shall be of copper and shall be rated to carry the rated symmetrical short circuit current of the associated board/panel for one second, unless otherwise specified. Earth bus bars shall be properly supported to withstand stresses induced by the momentary short circuit

current of value equal to the momentary short circuit rating of the associated switchboard/panel.

(c) Positive connection of the frames of all the equipment mounted in the switchboard to the earth bus bar shall be maintained through insulated conductors of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller.

(d) All instrument and relay cases shall be connected to earth bus bar by means of 1100 V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through the case earth terminals.

P. Internal Wiring

The internal wiring shall be carried out with 650/1100V grade, PVC insulated, stranded conductor wires. The minimum size of conductor for power circuits shall be 4 Sq.mm copper or equivalent size aluminium conductor. Control circuits shall be wired with copper conductor of atleast 1.5 Sq.mm.

Q. I / O & Other Data for Instrumentation, Control & Automation System

Necessary provisions shall be incorporated to meet the requirements indicated in

(a) I / O Schedules
(b) Data Transfer Schedule
(c) Alarm Schedule

Of Particular requirement of Instrumentation, Control & Automation System,Part-13, Volume -2.

R. Drawing and Data

All Drawings, data, technical particulars ,calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract asspecified, " Tender/Contract Drawings" , Part 2, General Requirements, Volume-2 of Tender Documents.

15.4 VARIABLE SPEED DRIVES/VARIABLE FREQUENCY DRIVES

The VSD/VFD must be designed specifically for the Water and Waste Water application.

The voltage source DC link frequency converters shall be provided for applications where speed of AC motors is required to be adjusted steplessly from approximately zero to maximum speed.

The unit shall be pulse width modulation (PWM) type with either open loop frequency control to keep the ratio of voltage and frequency (v/f) constant throughout speed range to maintain constant motor torque or vector control for

closed loop speed control with or without pulse encoder feedback where high speed accuracies and good dynamic performance of the motor desired.

The unit shall comprise incoming load-break isolator, line semiconductor fuses, moulded case circuit breaker (MCCB), main contactor as required, reactor, three phase rectifier as the line converter and three phase inverter as load converter interconnected through DC link reactor and capacitor unit.

The PWM inverter shall have fully digital microprocessor based regulation and control system with suitable interfaces for communication with plant automation system. The microprocessor based control shall carry out all the functions required from the unit including triggering, protections, self diagnostics and operator interface. Display of faults, alarms as well as diagnostic messages will be available in plain text on the operator panel mounted in the drive cubicle. All metering feature viz voltage, current, frequency for incoming and outgoing side shall be included in the panel.

Shielded power & control cables from drives to motor terminals shall be provided by the purchaser until and unless special cables are recommended by the drive manufacturer. Also, drive manufacturer shall indicate the maximum distance limitations from drives to motors to avoid output choke.

12 pulse or 6 pulse rectifier & inverter units shall be considered as required based on process requirement.

Duty of AC drives (heavy duty or light duty) shall be provided based on process requirement as per applicable IEC standards.

Short time voltage dips upto 80% of nominal (e.g. in case of large motor start-up connected to same bus) shall not cause the control system to stop functioning and shall not trip the drive system.

Drives shall be selected based on rating & application of motors, duty class, current, torque values, GD^2 value, speed range etc and ambient temp derating factor & altitude derating factor.

The drive motor shall be speed regulated corresponding to 4-20mA or 0-10V reference input signal. Upon complete loss of users speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to loss of the signal.

The required provision for interfacing with PLC/DCS, including details of communication module and data transfer facility, I/O details shall be furnished by the Bidder.

The required provision of interface module for pulse encoder shall be furnished by bidder.

The required provision of RTD and BTD inputs for motor winding and bearing temperature shall be furnished by bidder.

Local/Remote selection provision should be available in offered drive panel.

Protections:
Drive overload protection, phase loss, instantaneous over current, power loss ride through, ground fault, fin overheat, o/p short circuit protection, stall prevention, I/P & O/P open circuit protection, torque limit etc.

In addition to the standard motor protection functions, the VSD shall have pump protections functions to avoid damages to the pump.

- Inlet protection to avoid dry run (too low inlet pressure or flow)
- Outlet protection to avoid high pressure or high flow.
- Stall protection to avoid running locked pump
- End of curve protection to avoid running of pump away from desired operation curve

Provision for EMC Filters: To be provided. Harmonics to be limited to as defined by relevant IEEE standard.

Panels shall be free standing, floor mounting type, dust and vermin proof and shall comprise rigid welded structural frames enclosed completely with cold rolled sheet steel of thickness no less than 2.5 mm for front and rear portions and 2.0 mm for sides, top and bottom portions. There shall be sufficient re-inforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation.All doors, removable covers and panels shall be gasketed all round with neoprene gaskets. Ventilating louvers shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

Design, material selection and workmanship shall be such as to result in a neat appearance inside and outside with no welds, rivets or belt heads apparent from outside, with all exterior surfaces true and smooth.

All sheet steel work shall be phosphated in accordance with the following procedure and in accordance with relevant IS standard. The final finished thickness of paint film on steel shall not be less than 100 microns and shall not be more than 150 microns.

All terminal boards for outgoing connections shall be at a height of at least 250 mm from the cubicle floor, and preferably tilted at an angle of 45^0 to the horizontal for ease of connections. Similarly, connection of the incoming power cables to the bus bars shall be done at a height of at least 250 mm from the cubicle floor.

Testing

All routine tests shall be carried out on various devices / assemblies in line with codes & standards indicated.

Acceptance Test

These shall be conducted at the works of the VENDOR''S and/or his sub-vendor to ascertain that performance stipulated in this specification has been honoured (e.g. overcurrent capability, measurement of ripple voltage & current, P.F. measurement, Audible noise, etc). Dummy loads as required for the purpose of simulating the operation conditions at the VENDOR''s works shall be considered in scope of this specification. However, should this not be possible, testing at site with the actual load shall be conducted to prove the performance of the power converters. All the meter, instruments, devices used for the testing purpose shall be properly calibrated by standard authorised agencies which shall be traceable to National Standards. For each such instrument proper validity of calibration shall be documented by Vendor.

15.5 415 V POWER CAPACITOR AND CONTROL PANEL

A. Applicable Standards

The capacitor and control panel conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern

Shunt capacitors for power systems	IS : 13340
Internal fuses and internal overpressure disconnectors for shunt capacitors	IS : 12672
Metal enclosed switchgear	IS : 3427 / BSEN 60298 / IEC : 60298
Code of practice for phosphating iron and steel	IS : 6005/BS : 3189
Specification for copper rods and bars for electrical purpose	IS : 613

B. Design Features

(a) The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.

(b) The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanised.

(c) The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an overvoltage on the units in parallel with it, which will result in the failure of the parallel units.

(d) The complete capacitor banks with its accessories shall be metal enclosed (in sheet steel cubicle), indoor floor mounting and free standing type.

(e) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphated and then painted with two coats of zinc rich primer paint. After application of primer, two coats of finishing synthetic enamel paint oven baked/stoved shall be applied.

(f) The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary louvers may be provided in the cubicle to ensure proper ventilation.

(g) Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of the latest edition of IS : 2834.

(h) Capacitors shall be of Mixed Dielectric of polypropylene and paper with internal element fuses. The impregnant shall be non PCB (poly chlorinated biphenyl) oil.

(i) Each unit shall satisfactorily operate at 135% of rated KVAR including factors of overvoltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any

overvoltage upto a maximum of 10% above the rated voltage, excluding transients.

(j) Unit Protection

Each capacitor unit shall be individually protected by an HRC fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An operated fuse shall give visual indication so that it may be detected during periodic inspection. The fuse braking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse may be internal or external to the capacitor case.

C. Power Capacitor and Control Panel

(a) Power capacitor and control panel shall be housed in metal enclosed cubicle. Power capacitor shall be housed in the lower compartment and capacitor control panel at top compartment.

(b) The control equipment including capacitors shall be mounted in a panel of cold rolled sheet steel. The panel shall be of indoor type and shall consist of :

(c) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity

(d) Isolating switch

(e) Contactor with overload element

(f) Relays responsive to current/voltage/KVAR/PF as specified for automatic switching

(g) Sequencing devices, timers and auxiliary relays for automatic sequential switching of the capacitors in and out of the circuit.

(h) Auto-manual selector switches

(i) Push button for opening and closing the power circuit.

(j) Red and green lamps for capacitors ON/OFF indication.

(k) Protective relays to protect the healthy capacitor units when one unit fails in a series connection

(l) Space heater and cubicle lighting as per the requirements.

D. Drawings and Data

All Drawings, data, technical particulars ,calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified, " Bid/Contract Drawings" , Part 2, General Requirements, Volume-2 of Bid Documents.

15.6 415V BUS-DUCT

(a) All bus-ducts will be of non-segregated metal enclosed phase with cross over chamber (if required), all bends and accessories like flexible expansion joints, terminal connectors and flanges, wall frame assembly etc.

(b) The Bus-bar shall be of no-segregated Aluminium bus duct.

(c) The metal enclosed bus duct shall be designed to operate continuously under the conditions specified in Data Sheet.

(d) The material of the enclosure shall be CRCA with minimum thickness of 2 mm.

(e) Bus-duct enclosure will be of MS epoxy painted with outer shade of Siemens grey RAL 7032 & black matt paint on the inside. Paint thickness shall be 140 microns or above.

(f) Wall frame assembly shall be provided if required.

(g) The enclosure shall be totally enclosed, dust & vermin proof with ventilation louvers.

(h) All nuts, bolts, hardware used for Bus-duct shall be of M12 size, grade 8.8 & of cadmium.

(i) All joints in the enclosure shall have neoprene gaskets.

(j) The Bus-duct shall comply with the technical parameters of the latest version of the IS/ IEC.

(k) The bus duct shall be inclusive of the following:

i. Straight run of the duct
ii. 90 deg bends
iii. Copper flexible at Transformer end
iv. Copper flexible at LT DG end
v. Copper flexible at LT panels end.

vi. Wall frame assembly and seal off bushing
vii. Phase crossover chamber

(l) The bidder shall submit type test certificates along with the bid for Bus duct for
The following:
i) S.C. withstand capacity for 1 second.
ii) Degree of protection.
iii) Temperature rise.

15.7 DIESEL STANDBY GENERATOR

A. Applicable Standards

The Diesel Standby Generator and its components shall conform to the latest applicable
Standards specified below:

Diesel Engines for General Purposes	BS 5514 / ISO 3046
The Electrical Performance of Rotating Electrical Machinery	BS 5000
Rotating Electrical Machines	IS 4722
Circuit breakers	IS-13118, BS-5311, IEC-56 & 694, BSEN-60942 (P-2)
Air break switches air break disconnectors, air break switch disconnectors and fuse combination units for voltage not exceeding 1000 V AC or 1200 V DC	IS-13947 (P-3), BS-EN60947, IEC-60947-3
Current transformer	IS-2705/BS-7626, IEC-60185
Voltage transformer	IS-3156/BS-7625/IEC 60186
Electrical Relays	IS-3231,3842/BS-142/IEC-60255
Contactors for voltage not exceeding 1000 V ac or 1200 VDC	IS-13947 Part-IV/ BSEN-60947-4-1/ IEC-60947-4-1
Control Switches	IS-6875/BSEN-60947 / IEC-60947-4-1
High Voltage Fuse	IS-9385/BS-2692/ IEC-60282
Low Voltage Fuse	IS-13703/BS-1362 IEC-269-1
Electrical direct acting indicating Instruments	IS-1248/BS-89/IEC-60051
A.C. electricity metres of induction	IS722, 8530/BS-5685 / IEC-

type voltage greater than1000 volts	60145, 60211
Resistance wire, tapes and stripes for heating elements	IS-3725
Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes	IS-5082
Specification for copper rods and bars for electrical purposes	IS-613
Toggle switches	IS-3452/BS-3676
Control switches/push buttons	IS-6875/BSEN 60947
Noise and Emission Limit	As per latest notification of ministry of Environment and Forests

B. General Requirements

(a) The diesel engine shall draw cooling air directly from outside the room through a weatherproof, acoustically treated duct. The exhaust system shall be insulated to minimize the amount of heat entering the room and to prevent injury to personnel. The exhaust system pipe shall be 2 Meters above the nearest building as per CPCB. The exhaust pipe line diameter shall be suitably designed to avoid back pressure when discharged at higher elevation. The silencer shall be of the 'residential' type and be located externally.

(b) The generation voltage shall be 415V for D.G capacity less than 2MVA and generation voltage shall be 11kV for D.G capacity more than 2MVA. Even if one D.G set is required for achieving the required capacity they shall be operated in parallel with necessary synchronizing arrangement with LCD.

(c) At no point D.G sets will be operating parallel with grid. The diesel engine fuel shall be stored in an above ground bulk storage steel tank to be located adjacent to the generator room at a site accessible for filling to local road tankers.

(d) The storage tank shall be sized to store fuel for 1 day running of the engine at full load. The tank shall be provided with fittings to permit the visual observation of fuel level and filling by local tanker operators. A level sensor shall also be mounted in the tank so that remaining fuel volume can be monitored at the generator / substation PLC and the operator stations in the SCADA room.

(e) The fuel storage tank shall be located in a bund capable of holding not less than 125% of the maximum storage tank contents. Fuel transfer pumps shall be provided to automatically transfer fuel from the bulk storage tank to a high level 990 litres day tank located in the generator room or generator skid mounted day fuel tank. A semi-rotary hand pump shall be provided to permit transfer of fuel in the event of a failure of the transfer pump.

(f) Any leakage from the pumps shall be routed to the bund. A system shall be provided within the generator room to detect fire, to raise a local audible alarm (manually silenced locally) and if a high level day tank is used, to automatically dump the day fuel back to the bulk storage tank.

(g) The Fuel system shall be constructed such that leakage of water, fuel or oil within the generator room shall be routed to a local sump where a detector shall be provided to raise an alarm. Adequate sensors shall be provided to detect the fault and shall be wired to control panel.

(h) The system shall be constructed such that the leakage of fuel or the accumulation of water within the fuel storage bund shall be detected and shall raise an alarm.

(i) All alarms shall be conveyed to the central HMI through the PLC.

C. <u>Diesel Generating Set Automatic Control</u>

(a) AMF Diesel Generator Set capable of automatic starting and picking the load within 30 seconds shall be provided to cater for emergency loads and lighting during mains power failure.

(b) Diesel generating set for use in auto mains failure mode shall have a three position automatic /off /manual selection and shall operate as follows:

(i) Automatic mode :
On occurrence of mains failure the following sequence shall be followed.

a) Mains to Generator changeover

- mains failure detected
- delay of 10 seconds
- generator is started and run up to speed
- time delay of 50 seconds
- mains supply is switched off
- generator supply is switched on

b) Generator to Mains changeover

- mains healthy detected
- manual changeover signal received,
- generator supply is switched off
- mains supply is switched on
- generator runs for 2 minutes and stops

All timer settings shall be adjustable.

(c) If mains power is restored during the initial one minute delay then the power shall be monitored for a further one minute and if it is still healthy, mains power shall be restored. The generator shall be stopped after a further 2 minutes of running on no load. If the generator fails to start after an initial period of cranking, two further attempts shall be made with an appropriate interval between each attempt. If the engine fails to start after three attempts the system shall shut down and a local and remote alarm shall be annunciated.

(ii) Manual mode:

(d) The generator shall run to the dictates of manual controls on the generator. No automatic changeover of mains to generator supply or vice versa shall take place. The generator shall be loaded by manual switching if required.

D. <u>Alternator for Diesel Generating Set& Biogas Generator Set</u>

(a) The generation voltage shall be 415V for capacity less than 2MVA and generation voltage shall be 11kV for capacity more than 2MVA.

(b) Alternator shall be 4 pole, 3 phase,50 Hz, 0.8 P.F, salient pole, revolving field, Brush less type, self-regulating continuously rated and manufactured in accordance with IS 4722, BS 5000: Part 99 or IEC 60034-1. They shall be totally enclosed, screen protected, fan ventilated and vertical drip-proof conforming to IP 23.

(c) The Alternator shall be complete with excitation system, AVR and all necessary auxiliaries. The alternator shall be driven by diesel engine detailed below and shall match the same in all respects.

(d) The terminal box shall be dustproof with IP 54 degree of protection. The terminal box shall be suitably sized to terminate the size and number of cables involved.

(e) Alternators shall be capable of withstanding a 10% overload for 1 hour in any 12 hour Period under the specified conditions of temperature, humidity and atmospheric pressure. Alternator windings shall be of Class H insulation with Class F temperature rise and tropicalised.

(f) The alternator shall have pre-packed grease lubricated ball or roller bearing sand provided with facilities for degreasing whilst in service. The alternator shall be foot mounted on a common bed frame with the prime mover close coupled to the engine flywheel housing. The direction of alternator rotation when viewed from the driven end shall be clockwise and phase voltage sequence UVW.

(g) The alternator vibration level shall not exceed the values defined in IS 12075.The alternator shall be capable of maintaining a short circuit current of three times full load current for a period of 10 seconds. The alternator shall be fitted with an anti-condensation Alternator shall have 6 Nos. duplex RTDs inside the stator winding. No individual harmonic shall exceed 1% and the total harmonic shall not exceed 3%.

(h) The alternator, it’s neutral and control panel shall be earthed as per relevant standards. Alternator rotor assembly shall comprise exciter rotor, full wave silicon bridge rectifier, surge protection device and salient pole rotating field system. The rotor shall be fitted with interconnected pole face damping windings. Voltage regulation shall be maintained to within ±2.5% for a power factor of 0.8 to unity, including hot to cold variations.

(i) The steady state frequency droop between no load and full load shall not exceed 5%.Transient voltage deviation following a step load of 60% of rated at a power factor of between 0.4 and zero shall not exceed 15% with a voltage recovery time to 97% rated voltage not exceeding 0.5second.

(j) The set shall be capable of continuous operation with a phase current imbalance of 33% of rated current whilst maintaining the output voltage within ±5% of rated. Alternator shall have sensors for alternator protection and shall be wired to control panel.

(k) The alternator shall be provided with class F insulation with temperature rise limited to that of class B insulation.

E. Diesel Engine for Generating Set

(a) Engine shall be four-stroke, direct injection, and turbocharged industrial machines. They shall be fitted with renewable wet cylinder liners if water cooled and shall be direct coupled to the alternator and mounted on a common rigid steel bedplate.

(b) Engines shall be rated for continuous duty at site ambient conditions with an inherent O/ L Capacity of 10% for 1 hour in any 12 hours.

(c) The engine shall be capable of running at full load for not less than 180 hours without maintenance adjustments and 10,000 hours between major overhauls. The maximum operating speed shall be 1 500 rpm. The range of manual adjustment shall not be less than ±5% of rated speed. The performance of engine governors under load conditions shall be to Class A2 in accordance with BS 5514: Part 4.

(d) Engine governors shall be suitable for remote control load sharing between identical engine units. In addition to any electrical over speed trips, there shall be a mechanical over speed device which shall operate at 120% of the rated speed. Re-setting of the over speed trip shall be possible by hand only.

(e) The steady state output speed drop between no load and full load shall not exceed 5%. The transient output speed deviation shall not exceed 10% for a step of 60%. Engines shall be designed to run on fuel oil complying with IS 1460 or BS 2869, Class A2.

(f) Engines shall be cooled by means of a water jacket, heavy duty air blast radiator with integral radiator header tank, circulating pump and engine driven pusher type fan. The fan shall draw air in from the vicinity of the engine block and discharge it through the radiator core. The radiator shall be mounted on the same bedplate as the engine and alternator on suitable vibration isolators and be arranged so that it is located directly behind automatic louvers set into the external wall of the engine room. A thermostatically operated by-pass valve shall be fitted in the cooling system to maintain an optimum operating temperature during starting and running conditions. Drain cocks shall be provided so that all the water can be drained from the system. A separate oil cooler shall be used for cooling the engine oil. A thermostatic by-pass valve shall be incorporated.

(g) Engine lubrication shall be by a closed circuit wet sump, forced feed system supplied by an engine driven pump fitted with pressure regulating and relief valves, sump suction filter and changeover renewable micro-felt full flow line filters. A hand operated semi-rotary oil pump shall be installed to carry out initial priming or to fill or empty the sump as required. The sump shall be fitted with an easily accessible drain point. The oil shall be of the grade recommended by the engine manufacturer.

(h) The starting system shall comprise 12 or 24 V heavy duty lead acid batteries (positioned on a floor mounted stand adjacent to the engine) connected by heavy duty flexible butyl rubber cables. Batteries shall be sized to give six consecutive starts of the engine at 0˚C. An engine driven alternator and charging system shall be provided. An automatic mains energized battery charger shall be provided, with sufficient capacity to maintain the battery in a condition to full fill the starting requirements.

(i) Barring (hand turning) equipment shall be provided so that the engine can be manually rotated for maintenance purposes. It shall be arranged so that normal starting of the engine is inhibited whilst the hand turning equipment is connected.

(j) Twin heavy duty air intake filters in accordance with IS 3169 or BS 7226 suitable for operating in dust laden atmospheres shall be fitted. The filters shall be of the paper element with pre-cleaner type. Turbo charger filters shall be fitted. Breathers shall be fitted with washable filters which are easily accessible for maintenance.

(k) Instrumentation shall be provided to monitor speed, oil pressure, oil temperature (sets larger than 250 kVA), and water temperature and battery charge current. The bedplate shall be of heavy gauge steel construction, stress relieved and free from distortion. Engine shall be provided with sensors for engine protection and shall be wired to control panel.

(l) Machined surfaces shall be incorporated for mountings and for levelling. Anti-vibration mountings shall be fitted between the bedplate and the floor to prevent vibrations being transmitted to the building. The mountings shall be adjustable for levelling purpose and shall be designed to resist horizontal movement of the diesel set.

(m) The fuel System shall comprise an engine driven feed pump with duplex filters, 990 litres day tank with supporting structure or generator skid mounted day fuel tank, with all inter connecting pipe work , flexible engine connection pipe etc.

F. <u>Diesel Generator Control Panel:</u>

(a) The control panel shall have provision such that inter-opera ability with instrumentation control system. The control panel with communication facility shall be separately mounted on anti vibration mountings and shall comprise the following:

(i) Breaker incorporating short circuit and overload trip

(ii) Earth fault protection for the Alternator
(iii) Alternator Over & Under Voltage Protection
(iv) Voltage Controlled Over Current Relay
(v) Voltmeter with built in selector switch /(digital)

- ammeter with built in selector switch / (digital)
- frequency meter
- Power Factor Meter
- KWH Meter (Multifunction meter)
- engine temperature and oil pressure gauge
- service hours run indicator
- key switch start and stop control
- operational status indicator
- anti-condensation heater and thermostat
- alternator anti-condensation heater controls
- mains fed battery charger
- Auto start on mains power supply failure facility
- Fails to Start (Alarm)
- Over / Under Voltage (Alarm)

- Battery Charger Fault (Alarm)
- Low fuel Oil Level (Alarm)
- Over Load (Alarm)
- Low Lube Oil Pressure (Trip)
- High Water Temperature(Trip)
- High Lube Oil Temperature (Trip)
- Electrical Protection Relays (Trip).

(b) A reset button shall be provided to cancel the alarm /shut-down condition prior to re-starting.

(c) Simple operating instructions shall be detailed on the fascia of the control panel. All alarm and trip status signals from diesel supply system, engine control panel and alternator protection shall be hard wired to a marshalling box for instrumentation control system.

G. Synchronising Panel

Whenever two or more sets are required to operate together, necessary synchronizing panel complete with circuit breaker, synchroscope, numeric relays, digital meters etc shall be provided. The Panel shall be floor standing, CRCA Sheet steel enclosed.

H. Acoustic Enclosure

(i) The DG Set shall be provided with acoustic enclosure, fully integrated, weather proof with superior finish for long and durable life.

(ii) The acoustic enclosure shall be CRCA sheet steel enclosed with necessary panels and doors, inside lining of fire retardant foam/glass wool as acoustic material.

(iii) The sound level shall be restricted to 75dB at a distance of 1 meter, under full load, free field conditions as per relevant standards.

(iv) The acoustic enclosure shall be certified to meet the emission norms.

I. Bulk Fuel Storage Tanks

(i) Bulk fuel storage shall be in accordance with the explosives norms and necessary approval shall be obtained by the contractor.

(ii) Tanks and fittings, etc shall conform to IS 803 or BS 799: Part 5The tank shall be constructed in mild steel and the fittings in materials other than:

(iii) Yellow brass, including low grade alloys of copper and zinc.

(iv) Lead and zinc.

(v) Galvanized metals.

(vi) Natural rubber.

(vii) The maximum fuel surface level below the point of entry of the vent shall not be less than 100 mm. The internal surface shall be cleaned and treated with temporary preservative, soluble in fuel oil, before shipment.

(viii) The following fittings shall be included:

(a) 600 mm diameter manhole complete with portable cover situated in the top of the tank complete with ladder to the interior.

(b) Dipstick, calibrated in litres with guide tube and striker plate.

(c) Local indication of fuel level to be given at a position where it can be easily read during fuel delivery.

(d) Filling pipe work and fittings complete with isolation valve and captive end cap. The filling point to be at the top of tank to prevent siphoning.

(e) Outlet pipe situated at the raised end of the tank not less than 150 mm above tank bottom, complete with check valve, isolating valve and end cap.

(f) Drain pipe situated at lowest point in tank complete with isolating valve and captive end cap.

(g) Inlet fittings for overflow pipe from daily service tank or tanks (where specified).

(h) Vent pipe situated at high level in the tank. The pipe shall rise continuously from the tank and terminate with an inverted `U' bend and vermin screen.

(i) External ladder for horizontal tanks more than 2 m diameter.

(j) Level sensors shall be included which are connected to Low fuel oil level.

J. Drawings

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates etc. shall be submitted along with the bid/ after award of contract as specified under " Bid/Contract Drawings" , Part 3, General Requirements, Volume-2 of Bid Documents.

15.8 BATTERY, BATTERY CHARGER & DCDB

a) Battery, Battery Charger shall be three phase incoming supply with breaker. DC equipment shall comply with IEC 60896 including those standards referred to therein.

b) General Requirements

Following items shall be covered in the Contract:

(i) 110 V Value Regulated Lead Acid Battery (VRLA)

(ii) Float-cum-boost charger for 110 V batteries

(iii) DC distribution board.

c) All connections between battery, battery chargers and DC distribution board shall be designed for effective segregation between positive and negative leads.

d) Back up time for batteries shall not be less than 30 min.

e) The system shall be complete with all mounting stands, insulators, interconnecting accessories etc all as per enclosed specifications and data sheets.

A. Valve Regulated Lead Acid Battery

DesignFeatures

Battery offered shall beValue Regulated Lead Acid Battery (VRLA) Type. The battery shall conform to the latest applicable standards specified below:
Stationary Value Regulated Lead Acid Batteries
Specification :IS 15549-2005

a) The equipment offered shall be complete with all parts that are necessary or usual for the efficient operation of the equipment, whether specifically mentioned or not.

b) The VRLA batteries shall be starved electrolyte type to allow recombining of generated oxygen internally. The battery shall be completely explosion resistant, shall tolerate freezing and shall not allow gases to escape during normal charging conditions. The battery shall not require any topping and be maintenance free.

c) All inter cell, inter modules and inter stack connectors shall be covered with heat shrunk FR/FRLS sleeves.

d) Containers, cell lids, safety vents, separators, connectors, electrolyte, shall conform to the relevant IS/IEC and safety standards. The cell containers shall conform to the safety requirements of UL 94 HB or equivalent safety standard. The safety vent shall be self resealing pressure regulating with flame arrestor. In case the batteries are proposed to be housed in a sheet metal or polymeric enclosure, the same is deemed to be included in the scope of the bidder. The enclosure for battery shall conform to the safety provisions of UL 1778 or equivalent standard.

e) The battery shall be complete with accessories and devices, including but not limited to the following:

i) Battery racks

ii) Set of intercell, inter- module and inter stack connectors as required for the complete installation.

iii) Accessories for testing and maintenance

f) Battery racks shall be constructed from steel. Metallic stands shall be painted with acid resistant paint after 2 coats of primer.The racks shall be rigid, mechanically strong, free standing type and free from warp and twist. The completed racks shall be suitable for being bolted end to end to form continuous row. Insulators shall be provided below the legs of the stands

(h) 1 set of accessories for testing and maintenance shall also be provided suitable for all the three battery banks.

i.	One	-	-3, 0, +3 volts DC voltmeter with built-in discharging resistor and suitable leads for measuring cell voltage.
iii.	Two	-	PVC aprons
iv	Two	-	Cell lifting straps
v	One set Each of	-	Terminals and cable boxes with glands for connecting cable as required. Spare connectors Spare vent plugs Spare nuts and bolts Suitable set of spanners

Drawing

All Drawings, data, technical particulars,calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified under, “Bid/Contract Drawings”, Part 3, General Requirements, Volume-2 of Bid Documents.

B. Battery Charger and D.C. Distribution Board

Applicable Standards

The battery charger and D.C. Distribution board shall conform to the latest applicable standards specified below. In case of conflict between the standards and this Specification, this Specification shall govern.

Basic climatic and mechanical durability tests for components for electronic and : IS:9000

electrical equipment		
Environmental tests for electronic and electrical equipments	:	IS:9000
Metal clad base material for printed circuits for use in electronic and telecommunication equipment	:	IS:5921
Transformers and inductors (power audio, pulse and switching) for electronic equipment	:	IS:6297
Printed wiring boards	:	IS:7405
Environmental requirements for semi-conductor devices and integrated circuits	:	IS: 6553
Terminals for electronic equipment	:	IS:4007
Factory built assemblies of switchgear and control gear for voltages upto and including 1000 V AC and 1200 V DC	:	IS:8623/BS:5486 / IEC:60439
Air break switches	:	IS:13947(Part–3)BSEN 60947-3
Miniature circuit breakers	:	IS 8828/BSEN:60898
HRC cartridge fuses	:	IS:9224/BS:88
Contactors	:	IS:13947 (Part – 3) /BS:775 / IEC:60158-1
Control switches/push buttons	:	IS:6875
Indicating instruments	:	IS:1248/BC:89/ EC:51
Degree of Protection	:	IS:13947-(Part 1) /IEC:60947-1
Climate-proofing of electrical equipment	:	BSCP:1014
Code of practice for phosphating iron and steel	:	IS:6005/BS:3189
Semi-conductor converters	:	IEC:60146
Semi-conductor rectifier equipment safety code	:	IS:6619
Specification for copper rods and bars for Electrical purposes	:	IS: 613

<u>Battery Charger</u>

(a) Battery charger shall be combined float-cum-boost type.

(b) The charger shall be static type composed of silicon controlled rectifiers (SCRs) and diodes connected in three phase full wave half controlled bridge circuit.

(c) The rectifier transformers for float and boost chargers shall be indoor dry type, double wound with delta-star connections. The BIDDER shall ascertain if taps are required and provide adequate number of primary and secondary taps, if necessary.

(d) The float charger shall be designed for supplying :
   (i) The D.C. loads specified under Sr.No. 8.19.2 of Vol II, Part-8 i.e. continuous load and short-time overload.
   (ii) The trickle charging current of the battery.

(e) The boost charger shall be designed for supplying the boost charging current of the battery.

(f) If the battery and charger are to be supplied by separate contractors, the charger Contractor shall coordinate with the battery contractor regarding float /trickle boost charging current & voltages required for the battery.

(g) Battery Charger shall be provided with facility for both automatic and manual control of output voltage and current and necessary selector switch shall be provided. Contractor regarding the float/trickle and boost charging current and voltages required by the battery,

(h) Performance
   (i) Float Charger
   The D.C. output voltage during float charging shall be stabilised within
   ±1% of the set DC bus voltage. Manual control shall be used if auto mode fails.

   (ii) Boost Charger
   For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. After a specified number of hours (adjustable) when the rated cell voltage is reached, the charger shall be returned to float charge status.

   - In case of combined float-cum-boost charger, the switching and control of high rate charge and return to float charge shall be by automatic controller/regulator. Manual control shall be used if auto-mode fails.

   - During boost charging following emergency measures shall be provided:

- If the AC mains supply fails, an arrangement shall be made to automatically connect the battery directly across the load.

- If the separate or spare float charger supplying D.C. load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes.

(i) Suitable filter Circuits shall be provided in the chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of D.C Loads.

(j) The D.C System shall be unearthed.

Charger Panel and D.C. Distribution Board

(a) Battery charger panel and D.C. distribution board shall be sheet metal enclosure free standing type with cable entry from bottom.

(b) Indications, controls and output voltage setting adjustments shall be on front panel. The Contractor shall submit a scheme for alarm and trip indication lamps on the cabinet and for fault annunciation contacts paralleled for remote annunciation.

(c) The components shall be liberally rated and housed in a well ventilated sheet metal cubicle complete with input and output terminals. Louvers shall be provided for ventilation backed up by fine wire mesh so that the degree of protection shall be equal to or better than IP-42.

(d) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.

(e) All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily and marked test pins.

(f) All components shall be accessible to the maintenance technician for easy disassembly and replacement. Access to parts of equipment shall be with minimum danger from all hazards.

(g) All components and modules shall be clearly and unambiguously marked and all wiring colour-coded and tagged.

(h) All power and control wiring within the cubicle shall be done with stranded copper wires. The power wiring shall be adequately sized for the required

rating. The minimum sizes for control wiring will be 1.5 mm^2 and for power wiring shall be 2.5 mm^2.

(i) Ground terminals with isolating links shall be provided.

(j) Cable glands shall be provided to suit the incoming and outgoing cables.

Components/Accessories

(a) The main items are listed below. However, additional items required for completeness or to meet the specified performance or operational requirements of the charger, shall be deemed to be included in the Contractor's scope. Instead of incoming ON/OFF switches, stricker fuses and contactors, the Contractor may provide suitably rated 3 pole MCBs with overload and short circuit protection and auxiliary contacts.

(i) One (1) set - Three phase full wave half controlled bridge rectifier circuit comprising silicon controlled rectifiers and silicon diodes complete with resistor/capacitor network for surge protection. The diodes/SCRs shall be individually protected by fuses with fuse fail indication.

(ii) One (1) Double wound, dry type, three phase suitably rated mains transformer.

(iii) One (1) set of suitably rated control transformers for electronic controller.

(iv) One (1) Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilisation of ±1% and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, set output voltage and phase failure or voltage unbalance.

The electronic controller shall be provided with following features.

- Boost current stabilisation of ±2% with AC input variation of voltage and frequency variation of ±10% and ±5% respectively.
- Boost charge current limiter with potentiometer to adjust the setting.

(v) Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually.

(vi) One (1) Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit.

(vii) One (1) Auto/Manual selector switch for selecting the mode of operation of the controller.

(viii) One (1) front panel mounted potentiometer for set point adjustment of output voltage in auto mode.

(ix) One (1) front panel mounted potentiometer for manual adjustment of voltage in manual mode.

(x) One (1) TP AC ON/OFF switch for float charger incoming.

(xi) One (1) set of HRC fuses complete with fuse fittings for AC input with suitable ratings and with trip indication.

(xii) One (1) set of the pilot lamps with series resistors to indicate float charger AC Mains 'ON' condition.

(xiii) One (1) AC contactor with suitably rated coil and three main and 2 NO + 2 NC auxiliary contacts, suitably rated thermal overload relay and ON/OFF control switch.

(xiv) One (1) set of HRC fuses complete with fuse fittings for the DC output, and with trip indication.

(xv) One (1) moving coil DC ammeter, with shunt, of size 96 x 96 mm and suitable range to read the float charger output current.

(xvi) One (1) Double pole DC ON/OFF rotary switch for float charger output.

(xvii) One (1) pilot lamp with series resistor to indicate float charger DC 'ON' condition.

(xviii) Annunciation System for the following

(a) AC Supply Failure.

(b) Rectifier Fuse Failure.

(c) Surge Circuit Fuse Failure.
(d) Filter Fuse Failure.
(e) Load Limiter Operated.
(f) Charger Trip.
(g) Battery on Float.
(h) Battery on Boost.

Power Electronic Components

(a) Diode and thyristors shall be of monocrystalline type silicon, capable of continuous output at specified voltages. It shall have high power efficiency.

(b) If many diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly. This may be achieved with the help of chokes. Also, care should be taken to select matched pairs of rectifier heat sink units.

(c) Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.

(d) Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.

(e) The diodes or thyristor banks shall be natural air cooled.

(f) The diodes or thyristors shall be protected against overvotage due to chopping surges with the aid of snubbers (i.e. resistor-capacitor combination and Metal oxide varister). It shall be ensured that normal load currents and especially fault currents are shared equally between parallel links, within the specified limits. To achieve this, great care shall be taken to design the layout of the rectifier links to ensure equal lengths of busbars and as near as possible identical contact resistance in each current path.

Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified “Bid/Contract Drawings” , Part 3, General Requirements, Volume-2 of Bid Documents.

15.9 CABLING SYSTEM: HV, LV, CONTROL AND TELECOMMUNICATIONS

A. Applicable Standards

The cables shall conform to the latest applicable standards specified below.

PVC insulated cables (For voltage upto 1100 V)	:	IS: 694
HRPVC & PVC insulated cables heavy duty	:	IS: 1554
Crosslinked polyethelen insulated PVC sheathed cables	:	IS: 7098
Low frequency cables and wires with PVC insulation and sheath	:	IEC: 60189-1 & IEC-60189-2
PVC insulation and sheath of electric cables	:	IS: 5831
Polyethylene insulation and sheath for electric cables	:	IS: 6474
Conductors for insulated electric cables	:	IS: 8130
Methods of test for cables	:	IS: 10810
Specification for drums of electric cables	:	IS: 10418
Specification for PVC insulated cables for electricity supply	:	BS: 6346
Specification for PVC insulation and sheath of electric cables	:	BS: 6746

B. Features of Construction

(a) XLPE Insulated HV Power Cables :

The Cables shall be 11 KV/ 11 KV (Un earthed) grade, heavy duty, stranded aluminium Conductor, XLPE Insulated, Conductor Screening by extruded Semiconducting Compound, insulation screening through Combination of semi conducting compound and non magnetic tape(Copper tape), inner sheath over laid up cores, galvanised steel wire /strip armoured (Aluminium wire armouring for single core cables), outer sheath of extruded black PVC Compound type ST-2. Core Identification shall be by printed numerals.

(b) LT Power Cables

(i) PVC Insulated Cables:

The Cables shall be 1.1 KV Grade, heavy duty, Stranded Aluminium/ Copper Conductor, PVC Compound type A insulated, inner sheathed, galvanised steel wire /strip armoured,black PVC compound type ST1 outer sheathed.

(ii) XLPE Insulated Cables:

The Cable shall be 1.1 KV Grade, heavy duty, stranded aluminium/ Copper Conductor, XLPE insulated, inner sheathed, galvanised steel wire/ strip armoured ,extruded black PVC Compound type ST2 outer sheathed.

(c) Control Cables:

The Cables shall be 1.1 KV grade, heavy duty, stranded copper conductor, PVC Compound type A Insulated, galvanised steel wire/ strip armoured extruded PVC type ST1 outer sheathed.

(d) Telecommunication Cables:

The cables shall meet the following requirements:

Conductor	Solid, tinned, annealed copper
Insulation	PVC insulation Type-A as per IS:5831
Twisting	The insulated conductors shall be twisted together to form twisted pairs or quads, these shall be stranded in concentric layers to form the cable core. The cable thus formed shall be tightly lapped with outer wrapping tapes. The interstices of insulated cable core shall be completely filled with viscose compound
Overall screening	With 0.075 mm Aluminium tape or 0.013 mm melinex tape, overlap not less than 30%
Other details	A suitable non-magnetic rip cord shall be laid longitudinally under the sheath.The armouring shall be of galvanised steel wires or galvanised single steel strip. The inner PVC sheath shall be of Type-A. The outer PVC sheath shall be of Type ST-1.

C. Cable Rating

a) The Contractor shall ensure that cable and wires associated with the distribution and control systems, plant wiring and all other installations throughout the Works are adequately rated for their use.

b) In assessing the rating of any cable or wire, the following factors shall be taken into account:

- Supply voltage and frequency
- Maximum voltage drop permissible
- Type and magnitude of load
- Fault level and duration related to circuit protection relays and fuses
- Circuit over current protection
- Route length and disposition of cables
- Ambient temperature
- Method of installation

c) All power cables shall be sized for continuous current carrying capacity at the ambient temperature of 45^0C. The design current of any circuit shall exceed the full load current of the supplied device by at least 10%. Power cables shall be sized to limit the maximum voltage drop to no more than 3 %.

d) Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 10%. The Contractor when sizing cables for the remote operation of shunt trip coils shall take due account of the voltage drop caused by the momentary current surge taken at the instant of energisation. HV and LV cables shall be sized for a fault clearance time of 0.5 seconds for the incoming feeders and 0.16 seconds for switchboard feeders controlled by circuit breaker.

D. Cable Colours

All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.

The colour coding should be as follows:

3 Phase	Red, Yellow And Blue
Single phase or DC	Red And Black
Earth	Green/Yellow
Control	Blue (DC), Red (AC)

E. Cable Conductors

Copper conductors shall be used for cables of sizes upto6 Sq.mm.Aluminium conductors shall be used for cables of size 10 Sq.mm and above. Cores of cross-sectional area greater than 1.5 mm^2 shall be stranded.Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm^2. Power cables shall be of a minimum cross-section of 2.5 mm^2.Internal wiring of control panels shall be of a minimum cross-section of 1.0 mm^2 flexible and stranded. Control cables shall be of a minimum cross-section 1.5 mm^2 for external use and 1.0 mm^2 for internal use.

F. Cable Numbering

All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Cables of different categories shall be tagged with the following subscripts and three digit numbers.

HV power
LV power
Control
Instrumentation
Protection
Telecommunicatio
n

G. Cable Drums

Cables shall be supplied in non-returnable wooden drums. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage.

The Bidder shall indicate in the offer, the maximum length for each size of cable, which can be supplied on one drum. The actual length supplied on each drum shall be within tolerance limit of ± 5% without any tolerance on total ordered quantity of each size of cable. Howeverbefore winding the cables on drums. Contractor shall obtain Employer’s approval for the drum lengths.

Each drum or coil of cable shall be accompanied by a certificate stating the manufacturer's name, cable size, and number of cores, length, result and date of tests as required in the Employer’s Requirements. Cables manufactured more than 12 months before delivery will not be accepted. All cables shall be delivered with cable ends effectively sealed by hygroscopic scaling caps. When a cable is cut from a drum both ends shall be immediately sealed to prevent ingress of moisture. Cables shall not be transported to site in loose coils but a number of short lengths of cable may be transported on the same drum. The

Contractor shall be wholly responsible for the purchase and/or hire costs of all cable drums and for the removal of these drums from site after use.

H. Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, Test certificates etc shall be submitted along with the bid/ after award of contract as specified, " Bid/Contract Drawings" , Part 3, General Requirements, Volume-2 of Bid Documents.

15.10 CABLE CARRIER SYSTEM

A. General

The cable carrier system covers the supply of cable racks, cable trays and its supporting accessories.

B. Applicable Standards

Steel for general structural purposes	:	IS: 2062
Dimensions for hot rolled steel beam Column channel and angle sections	:	IS:808
Code of practice for use of metal arc Welding for general construction in Mild steel	:	IS:816
Hot deep galvanising of iron & steel	:	IS:2629
Methods of testing uniformity of coating Of zinc coated articles	:	IS: 2633
Hot dip zinc coatings on structural Steel and other allied products	:	IS: 4759

C. Cable Racks and Trays

(a) All cable trays, vertical raceways, cable racks and cable tray supporting structures shall be hot dip galvanised.

(b) Cable trays shall either be run in concrete trenches or run overhead supported from building steel, floor slab, cable racks, cable cum pipe racks, etc,.

(c) Vertical trays/raceways and outdoor cable trays shall be covered by removable 16 gauge GS sheet covers.

(d) The size of ladder/perforated cable trays to be supplied and installed shall be 150, 300, 450, 600 and 800 mm wide.

(e) The mounting structures/cable racks shall be fabricated from standard structural steel members (channels, plates, angles and flats).

(f) The cable racks and supports shall be painted after installation with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint

D. Galvanising

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below;

(a) Fabricated Steel

Thickness less than 2 mm, but not less than 1.2 mm	340 gms/sq.m
	460 gms/sq.m
Thickness less than 5 mm, but not less than 2 mm	610 gms/sq.m
Thickness 5 mm and over	

(b) Fasteners

Upto nominal size M10	270 gms/sq.m
Over M10	300 gms/sq.m

Galvanising shall be carried out after all drilling; punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

15.11 LIGHTING SYSTEM

A. General Requirements

(a) Refer Part 12 - Particular Requirements, Volume-2 of Bid Documents for the requirements of lighting system.

(b) Conventional lighting shall be considered for indoor and outdoor lighting. LED Lightingcan be proposed subject to the approval of Employer.However general requirements of conventional lighting along with LED lighting have been described in the following sections.

(c) The Lighting system includes the following items.

(i) Lighting fixtures complete with Lamps and accessories.

(ii) Lighting system equipment

- Light control switches, receptacle units with control switch units, lighting wires, conduits and other similar items necessary to complete lighting system.

- Lighting fixture supports, street lighting poles and flood light towers.

- Main Lighting distribution board, lighting panels.

- Multi core cables for street, boundary and flood lighting.

(d) All Lighting Fixtures, luminariesshall be considered for Emergency Lighting and fed from Main Lighting Board supplied by both mains supply normally and DG Set during power failure.

(e) DC Emergency Lighting shall be provided for Control rooms of Switchyards SCADA room, Switchgear and Control room of Pump houses.

B. Applicable Standards

The design, manufacture and performance of equipment shall conform to the latest standards specified below.

Lighting Fixtures & Accessories

Electrical lighting fittings general and Safety requirements	:	IS: 1913/ BS: 4533
Code of practice for industrial lighting	:	IS: 6665
Calculation of co-efficient of utilisation	:	IS: 3646 (Part - III)
Industrial lighting fittings with metal Reflectors	:	IS: 1777
Decorative lighting outfits	:	IS: 5077
Dust proof electric lighting fittings	:	IS: 4012
Dust tight electric lighting fittings	:	IS: 4013
Flood lights	:	IS: 10322/BS: 4533
Luminaires for street lighting	:	IS: 10322 Part 5

Water tight electric lighting fittings	:	IS: 3553/ BS: 4533, 5225(I)
Bayonet lamp holders	:	IS:1258/BSEN 61184IEC:60061
Edision screw lamp holders	:	IS: 10276/BSEN 60238
Bi-Pin lamp holders for tubular fluorescentlamps	:	IS: 3323
Starters for fluorescent lamp	:	IS: 2215/BSEN 60155
Holders for starters for tubular fluorescent Lamps	:	IS: 3324/ BSEN 60400
Ballast for use in fluorescent lighting fitting	:	IS: 1534 (Part1)/BSEN 60920& 60921
Transistorised ballast for fluorescent lamps	:	IS: 7027
Ballast for HP mercury vapour lamp	:	IS: 6616
Capacitors for use in fluorescent, HPMV & LP sodium vapour discharge Circuits		IS:1569/ BSEN 61048 & 61049 /IEC: 60586
Vitreous enamel reflector for tungsten Filament lamp		: IS: 8017
Tubular fluorescent lamps 60081	:	IS: 2418 (Part –1) /BSEN IEC: 60081
High pressure mercury vapour lamps 60188	:	IS: 9900/BS: 3677/ IEC:
Tungsten filament general electric lamps	:	IS: 418/IEC: 60432
Cast acrylic sheets for use in Luminaries	:	IS: 7569
Screwless terminal and electrical connections for lighting fittings	:	IS: 10322
High pressure sodium vapour lamps	:	IS: 9974
Emergency lighting units	:	IS: 9583

Ignition proof enclosures, dust-tight for Elect. Equipment	:	IS: 11005
Luminaires	:	IS: 10322 (Part I to V)
Lighting System Equipment		
Arrangement for busbars, main connections and auxiliary wiring and marking	:	IS: 5578/ 11353/BS: 159
Enclosed distribution fuse boards and cutouts for voltages not exceeding 1000V	:	IS: 2675/ BSEN 60439
General requirements for switchgear and control gear for voltages not exceeding 1000 V	:	IS: 13947
Code of practice - installation and maintenance of switchgear	:	IS: 10118/BS: 6423 BS 6626, BS 6867
Factory built assemblies of switchgear and control gear for voltages upto and Including 1000 V AC and 1200 V DC	:	IS: 8623/BS-5486/ IEC: 60439
Miniature air break circuit breakers for AC circuits	:	IS: 8828/ BSEN 60898
HRC cartridge fuse links upto 650 V	:	IS: 9224/BS:88/ IEC: 60269
‘D’ Type fuses	:	IS: 8187
Current transformers	:	IS: 2705/BS: 7626/ IEC: 60185
Voltage transformers	:	IS: 3156/BS: 7625/ IEC:60186
Direct acting electrical indicating Instruments	:	IS: 1248/BS: 89/ IEC: 60051
A.C. electricity meters	:	IS: 722/BS 5685

Electrical relays for power system protection	:	IS: 3231/BS: 142/ IEC: 60255
Switches for domestic and similar purposes	:	IS: 3854/BS: 3676
Three pin plugs and socket outlets	:	IS: 1293/BS: 546
Boxes for enclosure of electrical accessories	:	IS: 5133(1)
Rigid steel conduits for electrical wiring	:	IS: 9537/BS: 31
Accessories for rigid steel conduits for electrical wiring	:	IS: 3837/BS-31
Flexible steel conduits for electrical wiring	:	IS: 3480
Rigid non-metallic conduits for electrical Installations	:	IS: 9537/BS: 4607(2)
Fittings for rigid non-metallic conduits	:	IS: 3419/BS: 4607(2)
PVC insulated cables for working voltages upto and including 1100 V	:	IS: 694
Tubular steel poles	:	IS: 2713
Specification for copper rods and bars for electrical purposes	:	IS: 613
Code of practice for phosphating iron and steel	:	IS: 6005/ BS: 3189
Fittings for rigid steel conduits for Electrical wiring	:	IS: 2667

C. <u>Lighting Fixtures (Luminaries)</u>

(a) Luminaries shall be designed for continuous trouble-free operation without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather-proof and rain-proof type.

(b) The Luminaires shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.

(c) Connections between different components shall be made in such a way that they will not work loose by small vibration.

(d) For each type of Luminaires the Contractor shall furnish the utilisation factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.

(e) All Luminaires shall be supplied complete with lamps suitable for operation on a supply voltage withthe variation in supply voltage, frequency and combined voltage and frequency of ±10%, ±5% and ±10% respectively.

(f) The Luminaires and accessories shall be designed to have low temperature rise. The temperature rise above the ambient temperature shall be as indicated in the relevant Standards.

(g) Fluorescent type, metal halide type luminaires shall be complete with accessories like lamps, ballasts, power factor improvement capacitors, starters, re-wirable fuse and fuse base. These shall be mounted as far as possible in the luminaire housing only. If these cannot be accommodated integral with the Luminaires then a separate metal enclosed control gear box shall be included to accommodate the control accessories together with a terminal block suitable for loop-in, loop-out connections. Outdoor type fixtures shall be provided with outdoor type weather-proof box.

(h) Fluorescent type Luminaires with more than one lamp shall be provided with capacitors connected in lead-lag circuit for correction of stroboscopic effect.

(i) Each luminaire shall have a terminal block suitable for loop-in, loop-out and T-off connection by 250/400 V, 1 core, PVC insulated copper/aluminium conductor wires upto 4 sq.mm in size. In outdoor areas the termination at the luminaire shall be suitable for 1100 V, PVC insulated, copper/aluminium conductor, armoured cables of sizes upto 6 sq.mm conductor. Terminals shall be of stud or clamp type. The internal wiring should be completed by means of standard copper wire of minimum 1 sq.mm size and terminated on the terminal block. Terminal blocks shall be mounted with minimum two fixing screws.

(j) Mounting facility and conduit knock-outs for the luminaries shall be provided.

(k) Earthing

    (i) Each luminaire shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.

(ii) Where separate control gear box is provided for housing the accessories the same shall be provided with an earthing terminal suitable for connecting earthing conductor of 12 SWG GI wire.

(iii) All metal or metal enclosed parts of the luminaire/control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

(l) Painting/Finish

(i) All surfaces of the Luminaire/Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.

(ii) When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.

(iii) The luminaire housing shall be stove-enameled/epoxy stove-enamelled-vitreous enamelled or anodised as indicated under various types of fittings.

(iv) The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 deg. over 1/2” dia. mandrel.

(v) The finish of the luminaire shall be such that no bright spots are produced either by direct light source or by reflection.

(vi) External control gear box provided for housing accessories shall be painted or galvanised.

D. <u>LED Lighting</u>

(i) High Power White LEDs used in the luminaries shall have wattage greater than ONE watt.

(ii) LED shall be operated at a forward current of less than 90% of the rated current.

(iii) Colour Rendering Index (CRI) of the LEDs used in the luminaire shall be greater than 70.

(iv) The illumination of the luminaire shall be uniform without dark bands or abrupt variations and soothing to the eye.

(v) Light Uniformity Ratio (E_{min} / E_{avg}) would be > 0.4.

(vi) Luminary Body Temperature would be less than 30 ^{0}C above the ambient, even after continuous burning of Luminary for 24 Hrs.

(vii) The Luminaire works on single phase three wire system (Phase, Neutral & Earth).

(viii) The luminaire housing is made up of Corrosion free High Pressure Aluminum die cast thus confirming the luminaire to IP-68 protection and safety as per IEC 60598-1.

(ix) The Luminaire is equipped with distortion free, clear, Heat Resistant toughened, UV stabilized glass cover in the front fixed to the die cast Aluminum frame which would be fixed to the housing by means of stainless steel screws.

(x) The **minimum technical specifications for LED lighting** will be as follows:

a) Powered by the latest bright LEDs with high efficiency and meeting LM-80 standard.

b) Average rated life span of 50000 hrs.

c) LED efficacy shall be greater than 125 Lumens/watt.

d) Luminaire efficacy of at least 80 Lumens/watt.

e) Input voltage range 90-300 V.

f) Power factor > 0.9.

g) THD < 15%.

h) Ingress protection as per IP 68 for outdoor luminaries

i) Operating temperature -5°C to 50°C

j) Storage temperature -5° to 70°C

k) Humidity 10% - 100%

l) LEDs shall be operated at a forward current less than 90% of its rated current.

m) The LEDs used in the luminaire shall have minimum angle of 120 degree.

n) Colour rendering index (CRI) of the LEDs shall be greater than 70.

o) Conform to Photo Biological Safety for the LEDs as per IEC 62471.

p) Free replacement warranties of 5 years for technical defects.

E. Decorative Luminaries

Fluorescent Luminaries

(a) These luminaires shall be generally indoor type provided with cold rolled cold annealed (CRCA) sheet steel channel/rail cum reflector housing complete with all electrical control accessories mounted on it. The finish shall be stove enamelled.

(b) Decorative fluorescent type luminaires shall be either open type, provided with translucent white opal acrylic diffusers, polystyrene lens prismatic or square polystyrene louvers.

(c) Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column pendant mounting or for recess mounting in false ceiling.

(d) Decorative luminaires with mirror optic reflectors shall be of the wide angle dispersion type. Where these luminaires are mounted in control rooms and computer rooms, clip-on type adjustable reflectors which can be attached onto the tube shall be provided to direct the light output in the desired direction. This is mainly to reduce reflection of the light source from TV/monitor screens.

(e) Luminaires mounted recessed in false ceiling shall be with reflector housing and spring loaded fixing arrangement for the diffuser/louver frame. It shall be possible to have access to the lamp and other accessories from below.

F. Industrial Luminaries

Fluorescent Luminaries

(a) The luminaire shall be provided with CRCA sheet steel mounting rail with reflector of minimum 20 SWG thicknesses and complete with all control accessories mounted on it. The finish shall be vitreous enamelled.

(b) Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column/pendent mounting.

(c) The distribution of light shall be such that at least 80% of the total luminous flux from the luminaire shall be in the lower hemisphere.

(d) The luminous output of the luminaire with reflector shall not be less than 75% irrespective of type of reflector used.

G. Incandescent/ Mercury Vapourluminaires

Bulk Head Luminaire

(a) The luminaire shall be of robust construction, with cast aluminium/vitreous enamelled housing, heat and shock resistant prismatic or clear glass cover fixed with neoprene gaskets for sealing. For mechanical protection to the glass cover, round steel wire-guard with vitreous enamelled finish shall be provided.

(b) The luminaire shall be suitable for incandescent lamp upto 150 watts, for direct mounting to ceiling/wall/column and used for general purpose indoor lighting.

High and Medium Bay Luminaries

(a) High and medium bay luminaires shall be with cast aluminium housing, anodised aluminium mirror polished reflector canopy with eye bolt for suspension, cooling fins and glass cover.

(i) The luminaire shall be suitable for mercury vapour lamps upto 1000 watts and sodium vapour lamps upto 400 watts. The control gear accessories shall be mounted integral with the luminaire.

(ii) High bay luminaires shall be used when the mounting height is above 8 metres while medium bay luminaires shall be used when the mounting height is around 6 to 8 metres.

H. Flood Light Luminaire

General purpose flood light luminaire

(a) Flood light luminaires shall be of weather proof construction with cast aluminium housing, anodised aluminium mirror polished reflector, heat resistant, toughened glass cover and necessary neoprene gaskets to prevent ingress of dust.

(b) The housing shall be supported on a cast iron base and capable of being swivelled in both horizontal and vertical directions and locked in any desired position.

(c) For focussing purposes, knobs, shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg. in vertical direction.

(d) The Luminaires shall be suitable for single and dual mercury vapour or sodium vapour lamps upto 400 watts, incandescent lamps upto 1000 watts or halogen lamps upto 1000 watts. When mercury vapour or sodium vapour lamps are specified, the same shall be mounted in a separate sheet metal enclosed/cast aluminium weather proof control gear box.

(e) The luminaire shall be provided with cable gland on the canopy in down ward direction for cable connection.

(f) It shall be possible to adjust the lamp position to achieve wide beam, medium beam or narrow beam.

(g) It shall be possible to replace the lamp from the canopy without opening the front glass.

I. <u>Outdoor Lantern Luminaries</u>

Post top Lantern

(a) Post top lantern Luminaires shall be generally outdoor weather proof type for illumination of walkways, gate posts, gardens etc.

(b) The luminaire shall have cast aluminium spigot of 50/60 diameter finished with corrosion proof paint for mounting, opal acrylic or high density polyethylene (HDP) diffuser bowl, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.

(c) The luminaire shall be suitable upto 200 W incandescent lamp, 125 W mercury vapour lamps or 70 W sodium vapour lamp.

J. Sub-station Lantern

(a) Sub-station lantern shall be generally outdoor weather proof type for illumination of switchyard equipment.

(b) The luminaire shall have cast aluminium housing finished with corrosion proof paint, spigot for mounting on pole, prismatic glass refractor dome to give distribution of light in horizontal plane, anodised aluminium reflector to give light distribution at an angle 20 to 40 degrees, above the horizontal plane, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.

(c) The Luminaires shall be suitable upto 200 watts incandescent lamp, 125 W mercury vapour lamp or 70 W sodium vapour lamp.

K. Street Lighting Luminaries

Fluorescent Luminaries

(a) Street lighting fluorescent luminaire shall be outdoor weather proof type for illumination of secondary roads, walkways, peripheral lighting of buildings etc.

(b) The luminaire shall be of semi-cut off or non-cut off type, with CRCA sheet steel housing, vitreous enamelled, plain or corrugated clear acrylic cover, complete with integral mounted control gear, neoprene gaskets, side pipe entry or top suspension type.

(c) The luminaire shall be suitable for 1 x 40 watts or 2 x 40 watts fluorescent tubes and for mounting heights upto 4 metres.

L. Metal Halide luminaires

(a) Street metal halide luminaires shall be outdoor weather proof type for illumination of main roads, traffic islands etc.

(b) The luminaire shall be of semi-cut off with cast aluminium housing, acrylic or prismatic cover, polished aluminium reflectors, complete with integral mounted control gear, neoprene gaskets and with rear pipe entry.

(c) The luminaires shall be suitable upto 400 watts mercury or sodium vapour lamps and for mounting heights from 4 metres to 12 metres.

M. Portable Emergency Light Luminaire

(a) Emergency light of Installite luminaire shall be indoor type for providing emergency light during failure of normal AC supply.

(b) The luminaire shall be with CRCA sheet steel enclosure, complete with metallised mirror reflector, leak proof re-chargeable battery rated for two hour discharge, battery charger, charger-on lamp, push button switches, automatic changeover switch/relay, two metre length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaire.

(c) The luminaire shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal A.C. supply the luminaire shall pick-up automatically and on restoration of A.C. supply the luminaire shall switch off automatically.

(d) The luminaire shall be suitable for incandescent lamp upto 40 W or fluorescent lamp upto 20 W.

N. Accessories for Luminaries

Reflectors

(a) The reflectors shall be made of CRCA sheet steel/aluminium/silvered glass/chromium plated sheet copper as indicated for above mentioned luminaries.

(b) The thickness of steel/aluminium shall comply with relevant standards. Reflectors made of steel shall have vitreous enamelled finish. Aluminium used for reflectors shall be anodized/epoxy stove enamelled/mirror polished. The finish for the reflector shall be as indicated for above mentioned fittings.

(c) Reflectors shall be free from scratches or blisters and shall have a smooth and glossy surface having an optimum light reflecting coefficient so as to ensure the overall light output specified by the Contractor.

(d) Reflectors shall be readily removable from the housing for cleaning and maintenance without disturbing the lamps and without the use of tools. They shall be securely fixed to the housing by means of positive fastening device of captive type.

O. Lamp/Starter Holders

(a) Lamp holders shall have low contact resistance, shall be resistant to wear and shall be suitable for operation at the specified temperature without deterioration in insulation value. They shall hold the lamps in position under normal condition of shock and vibration met with under normal installation and use.

(b) Lamp holders for the fluorescent lamps shall be of the spring loaded bi-pin rotor type. Live parts of the lamps holder shall not be exposed during

insertion or removal of lamp or after the lamp has been taken out. The lamp holder contacts shall provide adequate pressure on the lamp cap pins when the lamp is in working position.

(c) Lamp holders for incandescent, mercury vapour and sodium vapour lamps shall be of Edison Screw (E.S.) type.

(d) The starter holders shall be so designed that they are mechanically robust and free from any operational difficulties. They shall be capable of withstanding the shocks met within normal transit, installation and use.

P. Ballasts

(a) The ballasts shall be designed to have a long service life and low power loss. The ballasts shall be of the inductive, heavy duty type copper wire wound, filled with thermosetting, insulating, moisture repellent polyester compound filled under pressure or vacuum. Ballasts shall be provided with taps to set the voltage within the range of variation in supply voltage of ±10% of 240 V. End connections and taps shall be brought out to a suitable terminal block rigidly fixed to the ballast enclosure. Ballasts shall be free from hum and such of those which produce hum shall be replaced by Contractor free of cost.

(b) Ballasts shall be mounted using self locking, anti-vibration fixings and shall be easy to remove without demounting the fittings. They shall be in dust tight, non combustible enclosures.

(c) Separate ballast for each lamp shall be provided in case of multi lamp luminaires, except in the case of 2 x 20 Watts luminaires.

Starters

(a) Starters shall have bimetal electrodes and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamps and without the use of any tool. Starters shall have brass contacts and radio interference capacitors.

Capacitors

(a) The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

(b) The capacitors shall be suitable for operation at specified supply voltage conditions and shall have a value of capacitance so as to correct the power factor of their corresponding lamps circuit to the extent of 0.95 lag or better.

(c) The capacitors shall be hermetically sealed preferably in a metal enclosure to prevent seepage of impregnant and ingress of moisture.

Lamps

Lamps shall be capable of withstanding small vibrations and the connections at lead in wires and filaments/electrodes shall not break under such circumstances.

(a) Incandescent lamps

(i) General Lighting Service (GLS) lamps shall be tungsten filament incandescent type. The filament shall be coiled coil type rated for 230/250 volts, Single phase A.C.

(ii) Lamps shall be with Edison Screw type metal lamp caps to prevent pilferage.

(iii) Lamps shall be milky white for diffused, soft, glare free lighting and rated upto 100 watts.

(b) Fluorescent Lamps

(i) Fluorescent lamps shall be low pressure mercury vapour type with low wattage consumption and high efficiency and longer burning life (about 2500 hours).

(ii) Lamps shall be of white light type suitable for operation on 240 V, single phase A.C. in standard lengths of 2, 4 and 5 feet and ratings upto 65 watts.

(iii) Lamps shall be provided with features to avoid blackening of lamp ends.

Q. Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as Specified, “Bid/Contract Drawings”, Part 3, General Requirements, Volume-2 of Bid Documents.

15.12 LIGHTING SYSTEM EQUIPMENT

A. Main Lighting Distribution Board and Lighting Panels (AC & DC)

(a) Constructional Features

(i) Boards and panels shall be sheet steel enclosed and shall be fully dust and vermin proof, providing a degree of protection of IP 52. Outdoor panels shall in addition be completely weather-proof with a sloping canopy for protection against rain and providing a degree of protection of IP 55. The sheet steel used for frame, frame enclosures, doors, covers and partitions shall be cold rolled 2 mm thick.

(ii) All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketed all round with neoprene gaskets. For the main floor mounted distribution boards with the switch fuse units arranged in tier formation, the hinged door of each unit shall be interlocked so as to prevent opening of the door when the switch is ON and to prevent closing of the switch with the door not fully closed. However, a device for by-passing the door interlock shall be provided to enable the operation of the switch with the door open, when necessary, for examination/maintenance. For wall mounting 1-phase ways lighting panels when provided with MCBs, a hinged, latched front door shall be provided with key-locking facility and a slotted backelite sheet shall be provided inside. Only the MCBs operating knobs or the fuse cap covers shall project out of the backelite sheet slots for safe operation and neat appearance. Incomer to lighting panels shall be provided with TPN MCB with ELCB.

(iii) All accessible live connections/metals shall be shrouded and it shall be possible to change individual fuses, switches, MCBs from the front of the boards/panels without danger of contact with live metal.

(iv) For floor mounting type distribution boards, adequately sized mounting channels shall be supplied and for wall/column/structure mounting type panels suitable mounting straps shall be provided.

(v) Adequate interior cabling space and suitable removable cable entry plates shall be provided for top/bottom entry of cables through glands and or conduits as required. Necessary number of glands to suit the specified cable sizes shall be provided. Cable glands shall be screwed on type and made of brass.

(vi) Two earthing terminals shall be provided to suit the earthing conductor.

(vii) All sheet steel parts shall undergo rust-proofing process which should include degreasing, de-scaling and a recognised phosphating process. The steel works shall then be painted with two coats of Zinc - chromate primer and two coats of final stove-enamelled finish paint of specified colour.

(b) Busbars

(i) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.

(ii) Busbars shall be provided with at least the minimum clearances in air as per applicable standards for 500 V, 3 phase system.

(iii) Busbars shall be adequately sized for the continuous current rating such that the maximum temperature of the busbars, busbar risers/droppers and contacts does not exceed 85° C under site reference ambient temperature.

(iv) The busbars, busbar connections and busbar supports shall have sufficient strength to withstand thermal and electro-mechanical stresses of the fuse/MCB's let through/cut-off current associated with the specified short-circuit level of the system.

(v) Busbar supports shall be made from suitable insulating material such as Hylam sheets; glass reinforced moulded plastic materials, permali wood or cast resin. Separate supports shall be provided for each phase of the busbars. If a common support is provided for all three phases, anti-tracking barriers shall be incorporated.

(vi) The neutral bus of the main 3 phase, 4 wire distribution board shall be rated not less than 50% of the phase busbars. The neutral bus of the 1 phase ways lighting panel shall be rated same as the phase busbars. The neutral bus should have sufficient terminals and detachable links for full number of single-phase outgoing lighting circuits.

B. <u>Panels/Boards' Component Equipment</u>

(a) Switches/Miniature Circuit Breakers (MCB)

(i) Switches/MCBs shall be hand operated, air break, quick make, quick break type conforming to applicable standards.

(ii) The switch shall be protected by fuse and the MCB shall be provided with overload/short-circuit protective device for protection under overload and short-circuit conditions. The minimum breaking capacity of MCBs shall be 6 kA R.M.S. at 415 V/220 V D.C.

(iii) Switch shall have provision for locking in both fully open and closed positions. MCBs shall be provided with locking facility.

(iv) The connections between switch and fuse shall be insulated and all live connections shall be shrouded.

(b) Fuses

(i) Fuses generally shall be of the HRC cartridge fuse-link type having a certified rupturing capacity of 80 kA at 440 V. Fuses upto 63A for distribution systems of medium short circuit levels may be of HRC cartridge screw-cap, D type, having a certified rupturing capacity of not less than 46 kA at 440 V and 16 kA at 250 V D.C.

(ii) Fuses shall be provided with visible indication to show that they have operated.

(iii) Cartridge fuses shall preferably be mounted in moulded plastic carriers. If fuse-carriers are not provided, insulated fuse pulling handle shall be provided for each size of fuse for each switchboard.

(c) Indicating Instruments and Meters

(i) Whenever required, instruments and meters shall be of the flush mounting type. They shall be suitably mounted so as to provide for easy access to CTs and small wiring.

(ii) Instruments shall be of minimum 96 mm square size, shall have provision for zero adjustment outside the cover and black numerals on white dial.

(iii) Watt-hour meters shall be of direct reading electro-dynamometer type complete with cyclometer type dials and reverse running stops.

(iv) Ammeter/Voltmeter selector switches having 3 positions and off, with stay-put contacts rated 10A shall be provided when specified.

(v) Potential fuses shall be provided at the tap-off point from the busbars for the voltmeters.

(d) Instrument Transformers

(i) Current and voltage transformers shall be of the dry type, of metering accuracy class 1.0. Unless otherwise specified, it shall be the responsibility of the Contractor to ensure that the VA burden of the instrument transformer is adequate for the meters connected to it.

(ii) Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests. Facilities shall be provided for short-circuiting and grounding the CTs at the terminal blocks.

(iii) Voltage transformers shall be provided with suitably rated primary and secondary fuses.

(e) Indicating Lamps

Indicating lamps shall be of the filament type and low watt consumption. Lamps shall be provided with series resistors.

(f) Internal Wiring

(i) Panels/boards shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with 650/1100V grade, PVC insulated, stranded aluminium/copper conductors. Conductors of adequate sizes shall be used to suit the rated circuit current.

(ii) Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire.

(iii) All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded rated 500 V, of reputed make, preferably stud type for higher current ratings such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current; the minimum rating shall be 20 A.

(iv) Terminals for circuits with voltage exceeding 125 V shall be shrouded.

(v) Terminals shall be numbered and provided with identification strip for identification of the circuit.

(vi) Terminal blocks for C.T. secondary lead wires shall be provided with shorting and disconnecting/earthing facilities.

C. <u>Labels & Diagram Plate</u>

(a) All door mounted equipment as well as equipment mounted inside the switchboard/panels shall be provided with individual labels with equipment designation/rating. Also the boards/panels shall be provided on the front with a label engraved with the designation of the board/panel.

(b) Labels shall be made of non-rusting metal, 3-ply lamicoid or engraved PVC.

(c) Inside the door of the 1 phase ways lighting panels a circuit diagram/description shall be fixed for reference and identification.

D. Light Control Switches

(a) Light control switches of ratings and types, i.e. decorative/industrial shall be supplied as required. The switches shall be suitable for use on 240 V, 1 Ph, 50 Hz supply.

(b) Switches shall be of flush type for mounting behind an insulated plate or incorporated with a switch plate for mounting flush with the surface of wall or switch box/suitable enclosure. The switch box/enclosure may be recessed into or mounted on a wall as per the requirement of project layouts.

(c) The size of enclosure boxes shall be chosen to accommodate the number of switches to be installed at the particular location. The enclosures shall be 18 gauge sheet steel galvanised. The enclosure box shall be covered with perspex/insulating cover. An enclosure intended for surface mounting shall not have holes or gaps in its sides other than those expressly provided for cable entry.

E. Receptacle Units

(a) Receptacle units shall consist of socket outlet with associated switch and plug. The socket outlet and switch or MCB shall be flush mounted within galvanised 18 gauge steel enclosure with insulation cover. The box may be recessed into or mounted on a wall as per requirements of project layouts.

(b) The receptacle units shall be suitable for 240 V, 1 ph - N, 50 Hz/415 V, 3 Ph - N, 50 Hz supply as required.

(c) Single phase receptacles shall be associated with a switch/MCB of same current rating and the receptacle shall become live only when the associated switch/MCB is in “ON” position.

(d) Three phase receptacles shall be associated with a TPN switch housed in the same enclosure. The receptacle shall become live only when the associated switch is in “ON” position.

(e) The plugs shall be provided with cord grips to prevent strain and damage to conductors/wires at connection and entry points.

F. Lighting Wires

(a) The wires for wiring in lighting system shall be 250/440 V, 1/C, PVC insulated, unarmoured with stranded copper conductors.

(b) The minimum area of conductors shall be 2.5 sq.mm. for light fittings and 5A Receptacles and 4 sq.mm for receptacles rated 15 A and above.

(c) The wires shall be coded white for phase/positive of D.C. and black for neutral/negative of D.C.

G. Conduits

(a) Rigid steel/non-metallic conduits and their associated fittings as required shall conform to applicable standards. The minimum size of conduit shall be 20 mm for surface installation and 25 mm for concealed installation.

(b) Steel conduits shall be seamed by welding and hot dip galvanised. They shall be supplied in standard lengths of 5 m.

(c) Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work.

H. Junction Boxes

(a) Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas, 3 phase receptacles etc.

(b) The junction boxes shall be dust and vermin proof and shall be fabricated from 14 gauge sheet steel and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. Boxes shall be additionally weather proof.

(c) The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, HRC fuses as required.

(d) The terminal blocks, with specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 600 V, grade, one piece construction complete with terminals, insulation barriers, galvanised nuts, bolts and washers and provided with identification strips of PVC. The terminals shall be made of copper alloy and shall be of box clamp type.

(e) The boxes shall be painted with one shop coat of Red oxide zinc chromate primer followed by a finishing coat of paint.

I. Lighting Poles and Flood Light Pole Mounting

(a) Lighting poles for street lights and flood lights shall be of stepped tubular steel poles construction as per applicable standard. These poles shall be coated with bituminous preservative paint on the inside as well as embedded outside surface. Exposed outside surface shall be painted with one coat of red lead oxide primer. After completion of installation two coats of aluminium paint shall be applied.

(b) Poles for mounting flood lights shall be supplied whenever required and as per typical attached drawing. Unless otherwise specified, poles shall be painted with red lead oxide primer and two coats of aluminium paint. A steel ladder shall be provided. The length of each step of the ladder shall be at least 300 mm and spacing between two adjacent steps not more than 300 mm.

(c) The supply of poles shall be complete with fixing bracket/necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes. The required sizes of poles and the junction box shall be as indicated in the attached drawings.

J. Drawings and Data

All Drawings, data, technical particulars ,calculations, detailed literature, catalogues ,test certificates etc shall be submitted along with the bid/ after award of contract as specified, " Bid/Contract Drawings" , Part 2, General Requirements, Volume-2 of Bid Documents.

15.13 EARTHING AND LIGHTNING PROTECTION SYSTEM

A. General

(i) The earthing and lightning protection system covers earthing conductors, earth electrodes and accessories.

(ii) Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system. Crane rails,tracks, metal pipes and conduits also shall be earthed at two points.

(iii) Steel RCC Columns, metallic stairs and rails of the building housing electrical equipment also shall be connected to nearby earthing grid conductor. Metallic sheaths/ screens and armour of multicore cables shall be earthed at both ends. Metallic sheaths and armour of single core cables shall be earthed at the switchgear end only.

(iv) Every alternate post of switchyard fence shall be connected to the earth grid by GS flat and gates by flexible lead to earthed post.

(v) Each Continuous laid length of cable tray shall be earthed at minimum two places by GS/GI Flats to earthing system, the distance between the earthing points shall not exceed 30m.

(vi) Lightning Protection System shall compromise vertical / horizontal air terminations, down conductors, test limits and earth electrodes. Air terminations, down conductors and test links shall be of galvanised steel conductors and earth connection below the ground level shall be of mild steel.

(vii) Lightning Protection System down conductors shall not be connected to other earthing conductors above the ground level.

B. Applicable Standards

The earthing and lightning protection system shall conform to the Indian Electricity rules, and the latest applicable standards indicated below:

Code of Practice for Earthing	:	IS: 3043
Code of Practice for the Protection of Building and allied structure against lightning	:	IS/IEC: 62305
Hot dip galvanising	:	IS: 2629, 2633, 4759
Structural steel	:	IS: 2062& 808
Welding	:	IS: 816

C. Earthing Conductor

(i) The electrical installation shall where required be connected to the general mass of the earth by an earthing conductor. The material used for the earthing conductor shall be as follows:

(a) Conductors above ground shall be galvanised steelflat;

(b) Conductor buried in the ground or embedded in concrete shall be mild Steel,rod /flat.

(ii) Allowance shall be made for reduction in the cross section ofthe steel over the design life of the earthing system;

(iii) The earth electrode system shall comprise one or more earth electrodes, earthing network, mesh or a combination of these in order to obtain the required earth electrode resistance.

(iv) Earth electrodes where used shall be of heavy duty galvanised mild steel of not less than 40 mm NB and 3000 mm long. Where multiple electrodes are used they shall be separated by a distance of not less than the driven length.

(v) Each earth electrode pipe shall be welded at the top to a mild steel plate to which the earthing tapes shall be connected. These connections shall each be housed in individual concrete inspection chamber set flush to the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked `Electrical Earth'.

(vi) All materials used for the earth electrode installation shall be purpose made for the application and site conditions and shall be approved by the Employer’s Representative.

(vii) Unless otherwise stated all excavation for the installation of the earth electrodes and the inspection pit shall be carried out by the Contractor.

(viii) After the earth installation has been completed the Contractor shall demonstrate to the Employer’s Representative that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

(ix) Marker posts and plates shall be provided to mark the route of buried tape or conductor electrodes. The markers shall be similar to those provided for cable routes.

(x) <u>Lightning Protection System</u>

a) The need of lightning protection has been established by
   - Calculating theoverall risk factor for each building, structure etc., as per procedure given in IS/IEC 62305-2.
   - Analysing the zone of protection provided by air termination conductors on tall structures in the plant area.

b) Air termination system comprising of rods/mesh or combination of both will be provided and the following methods shall be used to determine the positioning of Air termination system will be as per IS 62305.
   - The protection angle method

- The rolling sphere method
- Mesh method

c) Air termination system will be connected to the earthing system by down conductors fixed along the outer surface of building. Number & layout of the down conductors will be as per IS/IEC 62305.

d) Each down comer will be terminated to a separate treated test earth electrode which in turn will be connected to station earthing system.

e) Test link will be provided in the run of each down conductor at approximately 1000 mm above ground level.

f) Air termination system shall be connected to earthing system below ground by down conductors. For this purpose separate treated earth pit to be constructed. The down conductors shall follow a direct path to earth. There shall not be any sharp bends, turns and kinks in the down conductors.

g) All joints in the down conductors shall be of welded/brazed type. All metallic structures within 2 meters from down conductors shall be bonded to lightning protection system.

h) The lightning protection system shall not be in direct contact with underground metallic service ducts, cables, cable conduits and metal enclosures of electrical equipment. However all metal projections, railings, vents, tanks etc. above the roof shall be bonded together to form a part of roof grid.

i) The lightning protection air termination rods and/or horizontal air termination conductors shall be fixed in such a way that they remain in their installed position even during severe weather conditions. The necessary accessories such as cleats, clamps, welding materials, bolts, nuts, shall be supplied by CONTRACTOR.

D. <u>Main Equipotential Bonding Conductor</u>

(i) Main equipotential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works. The conductor sizes shall be calculated as per IS 3043/IEEE 80 and any account of for the loss of material (steel) due to corrosion in soil has to be considered in the conductor size.

(ii) Equipotential bonding conductors shall have the following **<u>minimum sizes</u>**.

a) Main Equipotential Conductors

- Main Earth Conductor buried in earth 40 mm dia. MS Rod
- 11/0.433 kV transformers, main switchboard 50 x 10 mm flat
  and standby generator installation.
- interconnection to lightning protection system 50 x 10 mm
  flat interconnection to MCCs 50 x 10 mm flat

b) Equipotential Conductors

- interconnection to CP s 25 x 3 mm
  flat
- power factor correction capacitor panel 25 x 3 mm
  flat
- local push buttons 14 SWG
  wire
- lighting distribution board 4 SWG
  wire
- lighting and receptacle system 12 SWG
  wire
- outdoor street lighting 8 SWG
  wire
- ladder rack and cable tray at suitable points 25 x 3 mm flat
- hand rails and metallic structures 25 x 3 mm
  flat
- building reinforcement 25 x 3 mm
  flat
- incoming and outgoing process services 25 x 3 mm
  flat
- steel structures comprising storage tanks, 25 x 3 mm
  flatmezzanine platform, crane rails, air handling ductwork systems etc.
- LV Motors
- up to 10 kW 8 SWG
  wire
- 10 to 20 kW 4 SWG
  wire
- 20 to 50 kW 25 x 3 mm flat
- Earth electrode 40mm dia 3000 mm long heavy

Duty G.I. pipe electrode

Notes:

1 Equipotential conductors shall interconnect between the device to be bonded and the main equipotential conductor.

2 Connections to building structural steelwork or concrete reinforcement shall be made by a bolted connection to a tag welded to the steelwork or reinforcement bars. Unless otherwise specified at least two connections shall be made to the steelwork and reinforcement bars at the perimeter of each building at diagonally opposite locations.

E. Circuit Protective Conductors

(i) An independent circuit protective conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:

- a separate core within a multicore cable;

- a separate conductor installed within a conduit or trunking. Steel conduit or trunking shall not be used as a circuit protective conductor;
- The metal sheath of an armoured cable. The sheath shall be bonded to the metalwork of the apparatus and to the apparatus earth bar if any;

- the copper sheath of a mineral insulated copper sheathed cable;

- an independent earthing conductor MS or GS conductor run adjacent to the circuit it protects.

(ii) Circuit protective conductors associated with the main circuits supplying switchboards and large electrical loads, i.e. motors in excess of 75 kW shall form a separate core of a multicore cable feeding the device or shall be an independent insulated copper conductor run adjacent to the supply cable. The size of the circuit protective conductor shall be calculated in such a manner as not to take into consideration the contribution of any other parallel or fortuitous earth paths.

(iii) The armouring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.

(iv) Where the cable armouring or sheath is used as the circuit protective conductor it shall be securely bonded at both ends to the metalwork of the apparatus and to an earth bar. Particular care shall be taken to

ensure continuity across items of apparatus situated within a cable run and should the design of such items of apparatus not give adequate and lasting continuity through its structural body then additional earthing clips and conductors shall be provided to independently bond the cable sheaths together. Similarly additional earthing clips shall be provided to bond the cable sheaths/armour to any piece of apparatus fitted with a special earth terminal should the earth connection for the termination gland be inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.

(v) Instrumentation Earth

An instrumentation earth bus, if required shall be provided in each control panel. This shall comprise a copper flat of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and be provided with a single earth connection to the instrument earth. If due to the physical size of a control panel more than one instrument earth bar is required the additional bar shall be connected again with a single earth connection to the same point as before. In this fashion all instrument earths shall be connected radially from the same earth point.

(vi) The earth pit for instrumentation system shall be separate. Electric earth pits shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

(vii) SPDs associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturers recommendations.

F. Galvanising

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

a) Fabricated Steel

Thickness less than 2 mm,	
But not less than 1.2 mm	340 gms/sq.m
Thickness less than 5 mm, but not less than 2 mm	460 gms/sq. M
Thickness 5 mm and over	610 gm / sq.m

b) Fasteners

Upto nominal size M10	270 gms/sq.m
Over M10	300 gms/sq.m

Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

15.14 LIST OF MAKES/ MANUFACTURERS:

The list of preferred Makes/ Manufacturers is given below. **The items shall meet specifications. Mere mention of a make as approvedmake in the below list does not qualify for acceptance of an item.**

Equivalent makes can be proposed which meets the qualification criteria as mentioned in the notes below.

SL. NO.	DESCRIPTION	VENDOR / MANUFACTURER / MAKE
1	Distribution Transformers	M/s Crompton Greaves Limited M/s Volt Amp M/s Kirloskar Electric Co. Ltd. M/s. Kotsons
2	11 kV Metal enclosed switchboards	M/s Siemens M/s ABB M/s BHEL M/s Schneider Electric
3	Digital Protective Relays / meters	M/s ABB M/s Schneider Electric M/s Lauritz Knudsen M/s GE M/s Siemens M/s Mitsubishi Electric
4	Current Transformers - LT	M/s AE M/s ECS M/s Pragati M/s Kappa
5	Voltage Transformers - LT	M/s AE M/s ECS M/s Pragati M/s Kappa
6	LV Switchgears & Control gears (PCC’s / MCC’s / PDB’s)	M/s Schneider Electric M/s ABB M/s Siemens M/s GE M/s L&T M/s Mitsubishi Electric Note: Authorized license partners / System Integrators of above manufacturer’s shall be TTP certified for IEC 61439
7	LT Power Capacitors / Panel	M/s ABB M/s CG Power Systems M/s Universal M/s Madhav M/s BHEL M/sLauritz Knudsen M/s Mitsubishi Electric Note: Authorized license partners / System Integrators of above

Note:

All products shall be completely manufactured in the country of Origin as indicated. Assembled products shall not be accepted.

Note-1: In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

Note-2: In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following during detailed engineering:

(i) Copies of Type Test Certificate (testing done as per latest standards) not older than 5 years for the items offered.

(ii) Demonstrate that the proposed makes are “equivalent” to the approved makes. The contractor shall ensure that alternate makes proposed, shall comply completely to the tender specifications, before the same is submitted for approval.

(iii) Submit ISO certificates for the OEM.

(iv) Submit quality certificates that the equipment adheres to, as required under this contract.

(v) Submit product brochures for the proposed equipment, testing facilities, with information on spares availability and service setup in employer’s country.

(vi) Manufacturer involved in manufacture of specified proposed equipment for at least 10 years before bid date.

(vii) End user performance certificates for minimum 10 successful individual installations of similar size as per this contract with the proposed equipment and model no, commissioned & satisfactorily operating for at least 5 years before bid date.

(viii) Manufacturer to provide full contact information for each reference as part of submission.